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MICHIGAN STATE UNIVERSITY
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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
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CHANGING MARKET PATTERNS FOR SLAUGHTER LIVESTOCK IN SOUTHERN MICHIGAN

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DEPARTMENT OF AGRICULTURAL ECONOMICS

INTRODUCTION

THE SALE OF LIVESTOCK provides Michigan farmers with about one-fifth of their total cash receipts from farm marketings. Cattle and calf sales represent about 62 percent of the total receipts from livestock, while hogs account for 34 percent, and sheep and lambs about 4 percent.[1] Among the states, Michigan ranks 18th in the live-weight farm production of meat animals.[2]

Livestock production is concentrated in the southern half of the Lower Peninsula. According to the 1954 census, 84 percent of Michigan livestock sales' dollars were going to farmers in the area generally south of the Bay City-Muskegon line. Fig. 1 shows the geographic distribution of livestock sales within the southern Michigan area. Farmer sales of cattle and calves are more evenly distributed than are hog or sheep sales.

Significant changes appear to be taking place in livestock marketing. Since 1930, there has been a rapid growth in the number of auction markets. Central public markets have declined in relative importance. Packers have been locating plants at interior locations that are nearer to sources of supply.

Reliable information on the extent and nature of such changes is needed by marketing agencies, farmers, public officials, researchers and teachers. Such a study is now underway and is being coordinated over the entire North Central Region.

The first phase of this study was a farmer survey conducted in early 1957. The objectives of this study were: (a) to determine where

[1]Michigan Department of Agriculture (1957). Michigan Agricultural Statistics: June. 52 pp.
[2]U. S. Department of Agriculture (1956). The livestock and meat situation. Agricultural Marketing Service, U. S. Dept. Agr. LMS-85. 47 pp.

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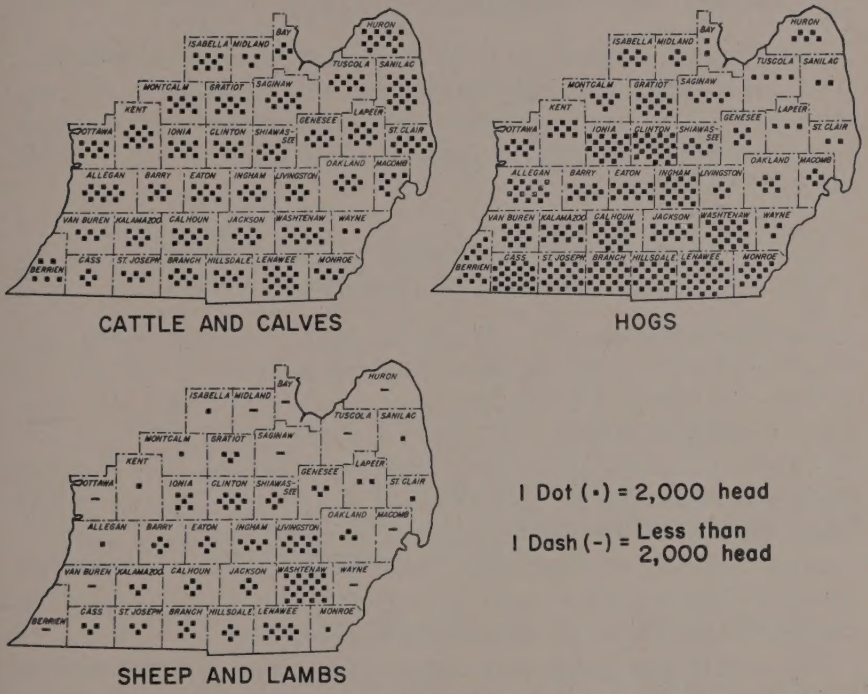

Fig. 1. Number of head of livestock sold by farmers, southern Michigan, (1954 census).

farmers sold and purchased livestock during 1956; (b) to compare 1956 market patterns with those reported in a 1940 study;[3] and (c) to obtain information on why farmers follow certain marketing practices.

This report summarizes some of the information obtained from farmers in southern Michigan. It is intended as a preliminary report on market outlets used in selling slaughter livestock. Subsequent publications will deal with other aspects of the study. A regional report on the farmer survey will also be available at a later date.

The second phase of the study is a survey of livestock marketing agencies. When the findings from this survey are combined with those from the farmer survey, it will be possible to identify more clearly some of the important livestock marketing problems.

[3]North Central Livestock Marketing Research Committee (1942). Marketing livestock in the corn belt region. S. D. Agr. Expt. Sta. Bul. 365 pp.

SOURCE OF DATA

This report is based upon data obtained by personal interview from 313 southern Michigan farmers who sold cattle, hogs, or sheep during 1956. An area sampling procedure was used to obtain a representative sample of livestock farmers.[4] Nine counties were entered during the survey.[5]

MARKETING AGENCIES AVAILABLE TO MICHIGAN FARMERS

Michigan farmers have several alternative market outlets for slaughter livestock. Among these are "terminal public markets" such as found in Detroit. Some farmers in southern Michigan ship livestock to terminal markets in Chicago and Indianapolis.

On March 1, 1957, there were 38 livestock "auctions" in southern Michigan where sales are normally held at least once a week. A few "local markets" exist where livestock is purchased from farmers; resorted; and sold to slaughterers, order buyers, or shipped to other markets. These markets have fixed facilities, such as pens, scales, loading and unloading chutes for handling livestock.

In several cases, auction facilities are operated as local markets in addition to the regular auction sale. Some of the "packers" buy livestock direct from farmers and take delivery at the farms, at the plant, or at yards located at other points.

There are about 960 licensed livestock "dealers" in the state. Some dealers buy slaughter livestock directly from farmers for resale at other market outlets, but much of the dealer buying centers around auction markets. A dealer who has facilities for receiving livestock (such as those cited previously for local markets) and who buys livestock as it is delivered to him from other farmers would be considered both a dealer and a local market. Local butchers, retailers, and farmers also provide a market outlet for a small percentage of the slaughter livestock.

LIVESTOCK SALES CLASSIFIED BY USE

The farmers surveyed were asked to classify their livestock sales as slaughter, feeder, herd or flock replacement. In some instances,

[4]For details on sampling procedures, see E. E. Houseman and T. J. Reed (1954). Application of probability area sampling to farm surveys. U. S. Dept. Agr., Agr. Marketing Service Handbook 67, Agricultural Marketing Service.

[5]The sample counties were Branch, Lenawee, Van Buren, Calhoun, Jackson, Eaton, Ionia, Macomb, and Sanilac.

TABLE 1—Percent of livestock sold for different uses reported by 313 southern Michigan farmers, 1956

Class of livestock	Total number of head	Percent sold for different uses				
		Slaughter	Feeder	Herd or flock	Use not known	Total
Cattle.....	2,290	86	3	10	1	100.0
Calves.....	1,320	80	14	2	4	100.0
Hogs.....	7,340	84	15	(a)	(a)	100.0
Sheep.....	2,405	99	(a)	(a)	...	100.0

(a) Less than 1 percent.

the use made by the buyer was not known by the farmer, but this occurred rarely (Table 1). As shown in Table 1, a very high percentage of total livestock sales were for slaughter; only a small percentage were for other purposes. A summary of information on the sale of animals sold for slaughter follows.

MARKETS USED IN SELLING SLAUGHTER CATTLE

Classes of Slaughter Cattle Sold and Size of Lots

Cull dairy cows, vealers, and deacon calves[6] made up 58 percent of the total number of slaughter cattle sold from the sample farms in southern Michigan (Table 2). However, dairy stock represents a somewhat smaller percentage of total dollar sales of slaughter cattle.

[6]Deacon calves are generally considered to be less than 1 week old.

TABLE 2—Number and classes of slaughter cattle sold by 313 farmers in southern Michigan, 1956

Class	Number of lots	Number of head	Average lot size
Cull dairy cows.....	376	598	1.6
Veal calves.....	356	532	1.5
Deacon calves.....	310	511	1.6
Total.....	1,042	1,641	1.6
Steers.....	110	738	6.7
Heifers.....	33	145	4.4
Mixed steers and heifers.....	45	283	6.3
Total.....	188	1,166	6.2

TABLE 3—Percent of lots and percent of total head of cull dairy cows, veal calves, and deacon calves sold by 313 southern Michigan farmers, 1956

Lot size	Percent of lots			Percent of total number of head		
	Dairy cows	Vealers	Deacons	Dairy cows	Vealers	Deacons
1.....	71.8	66.9	53.5	45.2	44.7	32.5
2-3.....	23.4	28.4	41.6	32.3	42.1	54.2
4 and over.....	4.8	4.8	4.8	22.6	13.2	13.3
Total.....	100.0	100.0	100.0	100.0	100.0	100.0

The average size of lot for dairy stock was 1.6 head. This was much less than the average of 6.2 head for all steers and heifers (Table 2). Nearly one-half of the cull dairy cows were sold individually, while lots of single animals made up more than 70 percent of all the lots sold (Table 3).

About 87 percent of the veal calves were sold in lots of three head or less, whereas only 12 percent of the steers and heifers were sold in lots of this size. About 24 percent of the steers and heifers were sold in lots of 20 head or more (Table 4). Here again, small lots are most common, with 85 percent of lots having less than 10 head of cattle.

Relative Importance of Market Outlets

Auctions and terminal markets are the two principal outlets used by southern Michigan farmers for the sale of slaughter cattle. The auctions hold a dominant position as an outlet for dairy animals, with

TABLE 4—Percent of lots and percent of total head of slaughter steers and heifers sold by 313 southern Michigan farmers, 1956

Lot size	Percent of lots	Percent of total number of head
1-3.....	42.6	11.8
4-9.....	42.6	46.0
10-19.....	9.6	18.4
20-49.....	4.8	19.3
50 and up.....	.5	4.5
Total.....	100.0	100.0

TABLE 5—Percent of different classes of slaughter cattle sold through various marketing outlets by 313 southern Michigan farmers, 1956

Outlet	Steers and heifers	Cull dairy cows	Vealers	Deacons
	percent	percent	percent	percent
Terminal	47.2	28.8	11.5	2.0
Auction	34.5	62.4	83.1	93.3
Dealer	.7	2.3	.6	0
Local market	2.1	1.8	3.9	1.8
Packer	10.7	2.3	.9	1.0
Other	4.9	2.3	0	2.0
Total	100.0	100.0	100.0	100.0

62 percent of the cull cows, 83 percent of the vealers, and 93 percent of the deacon calves moving to this type of market (Table 5).

However, the sales pattern for slaughter steers and heifers was considerably different, with nearly half of these animals being sold through terminal markets; while auctions received another third of this class of cattle. Direct sales to packers were more important for steers and heifers than on discarded dairy stock.

Market Outlets for Steers and Heifers Related to Size of Lot

There was a tendency toward greater use of the terminal market as an outlet for slaughter steers and heifers as lot size became larger (Table 6). For small lots of three head or less, local outlets such as

TABLE 6—Relationship between size of lot and market used for selling slaughter steers and heifers, 313 farmers in southern Michigan, 1956

Outlet	Percent of cattle		
	Lot size		
	1-3	4-9	10 and up
	percent	percent	percent
Terminal	16.7	52.2	50.2
Auction	36.2	38.8	29.3
Dealer	0	1.5	0
Local market	14.5	.7	0
Packer	17.4	0	20.5
Other	15.2	6.7	0
Total	100.0	100.0	100.0

auctions, packers, local markets, farmers and others were used more than was evident on larger lots.

MARKETS USED IN SELLING SLAUGHTER HOGS

Size of Lots

Twenty-eight percent of the barrows and gilts were shipped in lots of less than 10 head, but these small lots made up 58 percent of all lots sold by the farmers contacted in this study (Table 7). Lots consisting of more than 20 head of hogs made up only 19 percent of the lots sold but accounted for 47 percent of the total number of head.

TABLE 7—Number of lots and number of head of barrows and gilds sold by 313 farmers in southern Michigan, 1956

Size of lot	Number of lots	Number of hogs	Percent of lots	Percent of hogs
1- 3	69	152	13.6	2.6
4- 9	226	1,450	44.7	24.9
10-19	116	1,508	22.9	25.9
20-49	88	2,289	17.4	39.2
50 and up	7	434	1.4	7.4
Total	506	5,833	100.0	100.0

In addition to the barrows and gilts, the sample farmers also sold 325 head of sows for slaughter. Thirty-six percent of the sows were shipped in lots of one to three head, 37 percent in lots of four to nine head, and 18 percent in lots of 10 head or more.

Relative Importance of Market Outlets

Nearly three-fifths of the slaughter hogs were sold through auction markets (Table 8). Local markets were second in importance, with 21 percent of the barrows and gilts moving through this outlet. Only about 10 percent of the slaughter hogs were being shipped to terminal markets. Direct sales to packers accounted for 7 percent of barrow and gilt sales.

Note that 29 percent of the barrows and gilts were sold either to local markets or to a packer where the farmer deals directly with one buyer. In this respect, the pattern of marketing for slaughter hogs differed from that for slaughter cattle.

TABLE 8—Relative importance of market outlets in the marketing of slaughter hogs, 313 farmers in southern Michigan, 1956

Market outlet	Barrows and gilts	Sows
	percent	percent
Terminal	10.8	9.8
Auction	57.6	58.8
Dealer	1.4	5.5
Local market	21.3	15.4
Packer	6.9	9.8
Other	2.0	.6
Total	100.0	100.0

Market Outlet Related to Size of Lot

There was no clear-cut relationship between size of lot and the type of market outlet used for barrows and gilts. Auctions consistently accounted for the bulk of the shipments, regardless of lot size (Table 9). There was a slight tendency toward greater use of terminal markets for lots of 10 head or more as compared with smaller shipments.

TABLE 9—Relationship between size of lot and outlet used for selling barrows and gilts, 313 southern Michigan farmers, 1956

Outlet	Size of lot			
	1-3	4-9	10-19	20 and up
	percent	percent	percent	percent
Terminal	5.3	6.3	19.8	8.6
Auction	65.8	58.8	52.1	59.6
Dealer	.7	.6	0	2.6
Local market	17.1	24.7	19.4	20.8
Packer	10.5	6.5	7.4	6.6
Other	.7	3.2	1.3	1.7
Total	100.0	100.0	100.0	100.0

TABLE 10—Number of lots and number of head of slaughter lambs sold by 313 farmers in southern Michigan, 1956

Size of lot	Number of lots	Number of lambs	Percent of lots	Percent of lambs
1- 9	30	173	33.0	7.6
10-19	26	337	28.6	14.8
20-49	19	559	20.9	24.6
50 and up	16	1,206	17.6	53.0
Total	91	2,275	100.0	100.0

MARKETS USED IN SELLING SLAUGHTER LAMBS

Size of Lots

Only 89 lots of lambs were sold by the sample of 313 southern Michigan farmers, but the average size of lot was 25 head. More than half of the lambs were sold in lots of 50 head or larger (Table 10). Only about 8 percent of the lambs were sold in lots of less than 10 head. Thus, it appears that the average size of lot for lambs is considerably larger than for hogs or the major classes of slaughter cattle.

Relative Importance of Market Outlets

Terminal markets handled 58 percent of the slaughter lambs sold by the farmers contacted in this study (Table 11). The only other market outlet receiving any appreciable volume of lambs was auction markets with about one-third of the total volume sold. The marketing pattern on lambs is in sharp contrast to that for slaughter hogs and

TABLE 11—Percent of slaughter lambs sold through various marketing outlets by 313 farmers in southern Michigan, 1956

Outlet	Percent
Terminal	57.6
Auction	33.5
Dealer	.3
Local market	4.1
Packer	1.8
Other	2.7
Total	100.0

cull dairy cattle where a much smaller percent now moves to terminal markets.

Market Outlet Related to Size of Lot

The market outlet used for slaughter lambs was sharply different for the small lots as compared with large lots (Table 12). For lots of 20 head or less, the auction markets are the principal outlet. For the larger lots, and particularly for lots of more than 50 head, the terminal market was the dominant outlet. The "other" outlet received no lambs except in lot sizes of 20 to 49; it accounted for about 11 percent of the total in that lot size. This 11 percent was sold by one farmer who sold his lambs through a lamb pool.

TABLE 12—Relationship between lot size and market outlet for slaughter lambs, 313 southern Michigan farmers, 1956

Outlet	Size of lot			
	1-9	10-19	20-49	50 and up
	percent	percent	percent	percent
Terminal	0	32.1	40.8	80.5
Auction	95.9	52.3	33.8	19.5
Dealer	4.1	0	0	0
Local market	0	15.6	6.7	0
Packer	0	0	7.6	0
Other	0	0	11.1	0
Total	100.0	100.0	100.0	100.0

Relative Importance of Market Outlets for all Slaughter Livestock

The wide variations in the value of different classes of livestock were taken into account in estimating the relative importance of markets as outlets for slaughter livestock.[7]

Based on this comparison, it was estimated that auctions handled about one-half of the total dollar volume of livestock sold by 313 southern Michigan farmers contacted in this study (Table 13). Terminals were second according to this measure of importance, with 27 percent of the total volume. Local markets ranked third in dollar

[7]Procedure for computing estimated value was as follows: Average price paid for each class of livestock sold in Michigan in 1956 was multiplied by average weight of each class of livestock sold in Michigan in 1956. This gave an average value per head for each class. This number was then multiplied by the total number of head of each class sold at each type of market outlet. The percent of total for each outlet was then computed. Information was obtained from Michigan Agricultural Statistics, June 1957, pp. 42, 48.

volume and packers fourth. The two principal markets, auctions and terminals, handled about 80 percent of the total dollar volume of livestock sold for slaughter.

TABLE 13—Percent of total dollar volume of livestock handled by different market outlets, based on sales of 313 southern Michigan farmers, 1956

Outlet	Percent of dollar value
Auction	52.6
Terminal	26.8
Local market	10.0
Packer	6.3
Dealer	1.3
Other	3.0
Total	100.0

CHANGES IN MARKET PATTERNS—1940 TO 1956

When the marketing patterns observed for 1956 are compared with patterns reported in a similar study made in 1940[8], some striking changes are apparent. Perhaps the most significant change has been the growing importance of auction markets as an outlet for slaughter livestock (Fig. 2).

Terminals have declined as a market for hogs and veal calves, but they have maintained their position or gained importance as an outlet for slaughter cattle and sheep. Farmer sales of slaughter livestock to dealers have declined for all classes of meat animals.

Fifty-seven percent of the slaughter hogs were sold through auctions in 1956, compared with 12 percent in 1940 (Fig. 2). Local markets have also gained in importance as an outlet for hogs. However, the facilities of an auction are occasionally used as a local market where the hogs are sold to an individual buyer without being offered for sale in the auction ring.

The combined volume sold through auctions or to local markets accounted for 78 percent of the slaughter hogs sold from southern Michigan in 1956. This compares with 28 percent going to these outlets in 1940. During this same period, the percent of hogs sold

[8]North Central Livestock Marketing Research Committee. Op. cit.

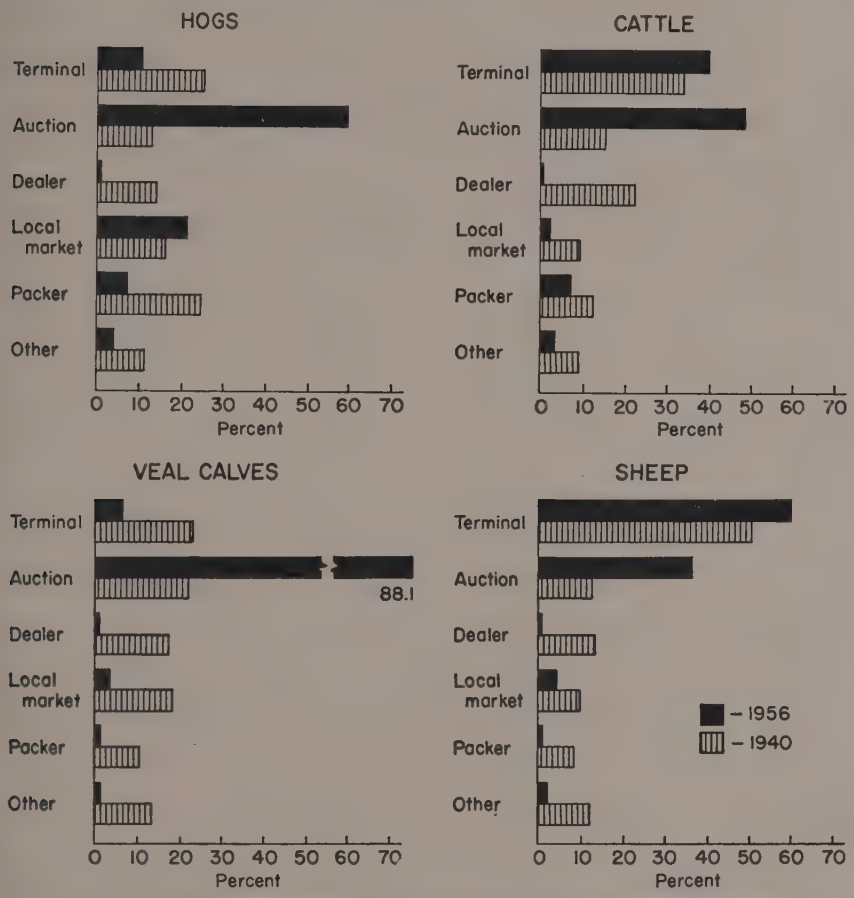

Fig. 2. Percent of livestock moving through different market outlets, southern Michigan. 1956 compared with 1940.

at terminal markets declined from 25 percent to 11 percent. Declines were also noted for sales to dealers and direct sales to packers.

Although the proportion of slaughter cattle sold through auctions rose from 14 percent in 1940 to 47 percent in 1956, this was not at the expense of terminal market sales (Fig. 2). Most of the increased auction volume replaced sales through dealers and, to a lesser extent, sales through other nonterminal markets. About 85 percent of the slaughter cattle were sold to auctions and terminals during 1956, compared with less than 50 percent in 1940.

The marketing of veal calves showed greater change since 1940 than did any other class of livestock. In 1940, veal calf sales were

fairly evenly distributed among terminals, auctions, dealers, and local markets with a smaller proportion moving through shipping associations or direct to packers (Fig. 2). By 1956, 88 percent of the veal calves were sold through auction markets. (Deacon calves and vealers were combined in the 1956 estimate.)

The percentage of slaughter sheep being sold through terminal markets increased from 48 percent in 1940 to 58 percent in 1956, giving this type of market a commanding lead over its nearest competitor, the auction market. However, during this same period auctions increased their share of total sales from 11 percent to 34 percent. Livestock shipping associations were still handling several lambs in 1940, but none of the 313 farmers surveyed in 1956 were selling sheep through this type of marketing organization.

The above percentage comparisons are subject to some degree of error when taken as estimates of the total market pattern for slaughter livestock in southern Michigan. In both 1940 and 1956, the estimated percentages sold through different market outlets were based on information from a sample of farms.

It is believed that the broad market patterns revealed in these data can be relied upon, but that small differences of 1 or 2 percent are probably not significant. Due to the sparseness of sheep production, the estimated percentages moving to various markets are probably less reliable than similar estimates for cattle and hogs.

SUMMARY

1. It is estimated that auctions and terminal markets received about 80 percent of the total dollar volume of slaughter livestock sold by 313 southern Michigan farmers during 1956.
2. Since 1940, auction markets have become the most important outlet for slaughter livestock sold by southern Michigan farmers. Terminal markets have declined as a market for hogs and veal calves, but they have maintained or gained importance as an outlet for slaughter cattle and sheep. Farmer sales of slaughter livestock to dealers have declined for all classes of meat animals.
3. The 1956 market patterns indicate that the relative importance of market outlets varies widely among different classes of slaughter livestock. Terminal markets received 58 percent of the sheep, 38 percent of the cattle, 11 percent of the hogs, and 7 percent of the calves.

Auction markets received 88 percent of the calves, 57 percent of the hogs, 47 percent of the cattle, and 33 percent of the sheep. Local markets received 21 percent of the hogs, but only 4 percent of the sheep, 3 percent of the calves, and 2 percent of the cattle. Packers were buying direct 7 percent of the cattle and hogs, 2 percent of the sheep, and 1 percent of the calves.

4. Terminals tended to increase in relative importance as a market outlet for steers and heifers and lambs as size of lot became larger.
5. Discarded dairy stock made up more than one-half of the total number of head of cattle and calves sold for slaughter in southern Michigan. The average size of lot for cull dairy cows and vealers was small, with about 95 percent of the lots being three head or less. Sales of single animals were most common.

FEEDING PENICILLIN FOR CONTROL OF BLOAT IN GRAZING CATTLE, AND ITS EFFECT ON MILK PRODUCTION[1, 2]

By R. S. EMERY, C. K. SMITH and C. F. HUFFMAN

DEPARTMENTS OF DAIRY AND MICROBIOLOGY

RUMINANTS PASTURED ON LEGUMES are prone to develop bloat (tympanites) through failure to eructate gas formed during rumen fermentation. This disease was observed as early as 60 A.D., but it has probably greatly increased with the development of good pastures containing legumes.

Our knowledge of bloat has been reviewed by Parham and Griffith (1956) and Cole et al. (1956). These reviews report an incidence of bloat ranging from 1 to 10 percent, with a mortality of from 10 to 20 percent of the bloated cattle during a pasture season. The loss of production resulting from the restricted use of legume pastures plus the loss of cattle has been estimated at 40 million dollars annually (Parham and Griffith, 1956). In terms of the Michigan cattle industry, this could mean 70,000 cases of bloat with over 300 deaths at an annual loss of over 1 million dollars in cattle and production.

Johns (1956) discussed the various current methods of bloat control such as pasture management, feeding roughage, and administration of various antifoaming agents. All of these methods have been in use for several years without appreciably reducing the incidence of bloat.

Barrentine et al. (1956) reported that feeding 50 to 75 mg. (milligrams) of procaine penicillin or its equivalent as potassium penicillin prevented bloat in yearling steers for 1.5 to 3 days. In a field trial, Barrentine et al. (1957) obtained practical control of bloat by the free-choice feeding of salt containing 800 mg. procaine penicillin per pound.

[1]Supported in part by the Hardy Salt Company, St. Louis, Mo.

[2]The authors acknowledge the help of county agents Blair G. Woodman, Mel Avery, Earl F. Haas and J. D. Johnson; extension dairyman George Parson; and all of the cooperating farmers.

ARTICLE 40-49

The work reported here sought to determine the practicability of using penicillin for control of pasture bloat on Michigan farms.

EXPERIMENTAL PROCEDURE

The occurrence of bloat was followed on 20 farms in Ingham, Clinton, Eaton and Shiawassee counties for 150 days (May 12 to October 8, 1957). The trial included a total of 110,790 cow days, or an average of 739 cows for 150 days. One herd was yearling Hereford feeder heifers while the others were Holstein, Guernsey, or Jersey dairy herds. The herds were chosen on the basis of interest and a past history of problems with bloat.

Fifteen herds were divided into approximately equal groups, and one of these groups was fed 100 mg. of procaine penicillin either daily or every third day (Group 1). The remaining cows in these 15 herds served as a control group and were managed in the same manner as the treated group with the exception of not receiving penicillin (Group 2).

Penicillin was fed on top of the grain mixture in a soybean oil meal carrier containing 850 mg. procaine penicillin per pound or in trace mineralized salt containing 3 gm. (grams) of procaine penicillin per pound on a free-choice basis to the other five herds (Group 3). The salt was usually replaced daily, and in no case was it allowed to remain in the box longer than 3 days.

All herds were visited about every 2 weeks to evaluate pasture conditions, observe feeding practices, and obtain histories on any occurrence of bloat.

As the season progressed, some portions of the control group were observed to be under slightly different management conditions from the remainder of the herd. These controls were then included in Group 4 for comparisons with Group 3 which was offered penicillin salt free-choice. However, this portion of the control group was discarded for comparisons between control Group 2 and Group 1 which were hand-fed penicillin.

Dairy Herd Improvement Association records were used to compare milk production between Groups 1 and 2. In addition, 40 cows in the University herd were assigned to five rations, and four cows on each ration were fed procaine penicillin mixed into their grain at the rate of 8 mg. per pound.

The daily intakes of penicillin for Groups 1 through 5 were 70.4, 63.2, 26.4, 48.8, and 54.4 mg. per day. The daily grain intakes were

8.8, 7.9, 3.3, 6.1 and 6.8 pound. Groups 2, 4 and 5 were fed the U. S. Department of Agriculture recommended amounts of grain; while Groups 1 and 3 were fed at 50 percent above and below these amounts, respectively. All groups grazed the same pastures. Group 5 received grass silage in addition to pasture and grain.

RESULTS AND DISCUSSION

The bloat incidence in Groups 1, 2, and 3 was 9.7 percent, with a mortality of 4.2 percent of the bloated animals. There was no bloat in the University herd during the 6-week trial. Bloat cases were rated from one to three on the basis of severity. A rating of one indicates a mild bloat with spontaneous recovery. A two rating described a cow in definite distress which was usually treated in some manner to relieve the bloat; and a three rating describes a death due to bloat or a cow which obviously would have died if prompt treatment had not been initiated. In the above groups, there were 39 cases of bloat with a rating of one, 26 cases with a rating of two, and seven cases with a rating of three. Three deaths occurred.

TABLE 1—Incidence of bloat days as affected by treatment

	(Group 1) Hand-fed penicillin	(Group 2) Controls	(Group 3) Free-choice penicillin	(Group 4) Controls
First 80 days (May 12 through July 30):				
Cow days bloated.....	3	27	33	42
Average number of cows ...	119.2	155.7	383.0	207.9
Percent bloat/150 days (*a*)	2.82 (*c*)	32.45	16.14 (*c*)	37.37
Percent control (*b*).....	91.3	.....	57.3	.....
Last 70 days (July 31 through Oct. 8):				
Cow days bloated.....	12	4	9	13
Average number of cows ...	246.7	128.8	295.0	136.5
Percent bloat/150 days...	10.42	6.65	6.53 (*d*)	20.38
Percent control.....	0	.....	68.0	.....
150 days (May 12 through Oct. 8):				
Cow days bloated.....	15	31	42	55
Average number of cows...	221.4	143.1	341.9	174.6
Percent bloat/150 days...	6.77 (*c*)	21.63	12.27 (*d*)	31.44
Percent control.....	68.7	.....	61.0	.....

(*a*) Percent bloat projected to 150 days so periods may be compared; bloat incidence times severity times 150 days times 100, all divided by average number of cows times 80 days.
(*b*) Percent bloat in control group minus percent bloat in treated group times 100, all divided by percent bloat in control group.
(*c*) Difference between treatment and control significant at 1 percent level.
(d) Difference significant at 2 percent level.

The incidence and severity of bloat days are summarized in Table 1. In compiling this table, the incidence of bloat has been multiplied by its rating. Thus, a bloat with a three rating occurring once reads as 3 days bloated. Although a significant reduction in bloat was obtained in both Groups 1 and 3 for the 150-day period, the bloat-controlling effect of penicillin apparently disappeared during the last 70 days for Group 1. This might be partially explained by the transfer of two herds with a high bloat incidence from Group 3 to Group 1.

Considering both experimental groups, there was a significant control of bloat over the entire experimental period, in spite of the loss of control as the season progressed. This problem might be overcome by feeding 50 mg. procaine penicillin daily during the first part of the season and gradually increasing this to 100 mg. as the season progresses (as done on one farm).

The salt consumption data in Table 2 indicate that Group 3 cows were consuming about 100 mg. procaine penicillin per day, although considerable variation occurred. This is particularly evident when it is considered that Farm 9 consisted of a herd of yearling Jersey heifers, compared to adult Holstein cows on Farms 6 and 15.

TABLE 2—Consumption of the penicillin-salt mixture (3 grams procaine penicillin per pound of salt)

Farm no.	Cow days	Other salt fed in grain	Lb. salt per cow per day	Mg. procaine penicillin per cow per day
9	11,760	No	0.047	141
12	870	Yes	0.046	138
3	4,800	Yes	0.031	93
6	8,260	Yes	0.029	87
15	6,750	Yes	0.029	87
18	16,800	No	0.027	81

It is believed that salt consumption was closely associated with availability. All farmers did a good job of keeping fresh salt in boxes at all times, but on some farms only one salt box was available for 50 to 100 cows. The leader or boss cows tend to push smaller animals from the box and, thus, limit consumption. Two small boxes seemed more desirable than one large box. Farm 9 had two salt boxes conveniently located and continuously available to about 70 head of heifers.

Considerable daily variation in salt consumption was also noted on some of these farms, particularly those with lactating cows. The cows on Farm 15 did not consume any salt for 2 or 3 days after each change to a fresh pasture. The one bloat case which occurred on this farm was during such a period.

In all cases, penicillin salt was the only free-choice source on all farms; any other salt fed was as part of the grain ration. The practice of including 1 percent salt in the grain did not appear to affect free-choice consumption in this trial.

Penicillin preparations were sampled on the farms for assay of penicillin activity by a paper disc method.[3] The freshly opened salt bags described in Table 3 had been stored for as long as 3 months.

TABLE 3—Penicillin stability

Age conditions / Salt (3gm./lb.)	No. of samples	Percent recovery of initial activity	
		Mean	Range
Freshly opened bag	3	113	(100-135)
Bag open 1 month	4	67	(58-79)
Bag open 4 months	1	86	
In box 2 days	1	100	
In box 3-4 days	2	50	(50-50)
Grain (0.83gm./lb.):			
Time after mixing			
1-3 months	7	99	(50-200)
1 year	1	65	

The penicillin is quite stable in this trace mineral salt formula as long as the bag remains sealed. This salt was packaged in 50-pound double-walled paper bags with an asphalt moisture barrier. When these bags were stored opened, the penicillin stability was sometimes poor. However, one open bag was stored for 4 months under dry conditions yet the penicillin activity was still 86 percent of initial activity. The penicillin grain mixture lacked uniformity, either due to poor mixing or separation with handling.

Samples of penicillin mixed with plain salt and with trace mineralized salt were aged for 30 days in open beakers in a room with high humidity and a temperature of 70° to 80°F. After this period, peni-

[3]Difco Laboratories, Inc., Detroit, Mich.

cillin recovery was 62 and 18 percent for the plain and trace mineralized salts, respectively. The trace mineral salt formula used in this trial decreased penicillin stability as compared to plain salt when stored under poor conditions, but there seemed to be little practical effect under good storage conditions.

Penicillin could not be detected in the milk from over 80 cows that had been hand-fed penicillin. The assay was capable of detecting less than 0.5 units penicillin per ml. milk.

Bloat incidence was usually greatest on pastures with an abundant growth and a high percentage of legumes. However, some bloat was observed on pastures with 10 percent or less of legumes. Cows were particularly prone to bloat when changed to a new and better pasture. The 20 farms seemed to be characteristic as to their incidence of bloat and the pattern it followed.

These farms can be separated into two groups, those with considerably more or less bloat than the 9.7 percent incidence given above. Table 4 shows a continuously declining incidence of bloat throughout the season, but individual farms varied greatly from this pattern.

TABLE 4—Incidence of bloat as related to season

Mean date	Percent bloat per 150 days (by 30-day periods)
May 26	29.0
June 25	22.1
July 25	12.0
August 24	6.3
September 23	5.7

The 144 monthly butterfat production records for the Group 1 penicillin-treated cows averaged 38.5 pounds, compared to 38.7 pounds for the 187 records from Group 2 control cows. The difference of 0.2 pound is not significant. A mean daily 4 percent fat corrected milk production of 27.2 pounds was observed for the penicillin-treated cows in the University herd, compared to 27.5 pounds for the controls. Neither this difference nor the difference attributable to rations was significant.

Note that results obtained in the two separate trials showed a slight depression of milk production in penicillin-fed groups. The

value of this milk must be added to the cost of the treatment if this is the case.

Experience obtained in other experiments[4] with penicillin by the authors indicates that a marked depression of milk production often occurs for several days after inclusion of 400 mg. procaine penicillin in the ration. This depression of milk production may be accompanied by loss of appetite and other symptoms, including discharge at the nostrils and hyperemia of the vaginal mucosa. All symptoms disappeared in a few days and production returned to normal, although penicillin feeding was continued. These symptoms were noticed in one herd during the field experiment in cows receiving only 100 mg. procaine penicillin. The problem was largely overcome in this herd by feeding only 50 mg. procaine penicillin for several days until the cows became adjusted to the treatment.

Assuming a retail cost of procaine penicillin in a suitable carrier to be 20 cents per gm., the following calculations can be made. Feeding 100 mg. procaine penicillin per cow per day to a 25-cow herd might cost 75 dollars per year or 750 dollars for 10 years. With the average bloat incidence of 9.7 percent and mortality of 4.2 percent found in this study, we would expect to lose one cow from bloat in a 10-year period in this 25-cow herd. The total loss of production in this herd plus the loss of one cow must then be compared with the 750-dollar cost of treatment.

The decision to feed penicillin in this herd depends upon the value of cows, milk and benefits derived from use of improved forage. As noted before, most farms seem to be distinctly above or below this average for incidence of bloat. Feeding penicillin should pay on those farms which have a bloat incidence above average.

SUMMARY

The incidence of pasture bloat was reduced by about two-thirds by feeding 100 mg. procaine penicillin per cow per day, either with the grain or in the salt on a free-choice basis. The efficiency of treatment appeared to decrease as the season progressed. However, bloat incidence in all groups, including controls, also showed a decline. An average incidence of bloat of 9.7 percent with a mortality of 4.2 percent of the bloated animals was found for 739 cows over a 150-day pasture season. The bloat incidence on individual farms was distinctly above or below this average.

[4]Unpublished work, 1957.

It is recommended that farms with a bloat incidence higher than this average feed 50 mg. procaine penicillin per cow per day and gradually increase the dose to 100 mg. as the season progresses.

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CHLORIDE TOXICITY OF FLOWERING STOCK AND SWEET PEAS

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GREENHOUSE CROPS IN MICHIGAN may be subjected to substantial amounts of the chloride ion from fertilizer (e. g., KCl) and tapwater (5) sources. Injury from excessive applications of the ion is indicated by a necrotic leaf tip (1, 2, 4, 7). This "firing" may extend to leaf margins; occasionally, necrosis may extend down the entire leaf blade (1). Older leaves are the first affected (7).

Healthy leaves generally contain somewhat less than 0.5 percent of dry weight as chloride (8, 16); while in injured leaves the concentration may vary between 0.4 and 3.5 percent, depending on the plant species (1, 4, 8, 16). This may be the result of 150 to 200 parts per million (p.p.m.) or more of chloride in the irrigation water (11, 17), or the application of as little as 150 pounds per acre of KCl in localized concentrations (10).

This study was designed to measure the effect of different amounts of chloride applied to two greenhouse crops while other essential elements were added at constant rates.

MATERIALS AND METHODS

To determine whether soil type alters the toxic effects of the chloride ion, two different soils were used. Brookston clay loam and Granby sandy loam were selected as soils comparable to those used in commercial greenhouses. The soil was steamed in 8-inch clay pots, previously coated with asphalt paint, and then thoroughly leached with distilled water for 4 days.

Seeds of flowering stock (Ball nonbranching Number 1 Lilac-lavender improved) were sown on February 4. Seeds of sweet pea (spring-flowering Cuthbertson strain Lois variety) were sown on February 16. The plants were watered as required with distilled water. The

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greenhouse was maintained at a minimum night temperature of 50° F.

On March 10, the stocks were thinned to six plants per pot and the sweet peas to two plants per pot, on the basis of uniformity of length. From this date, one-half liter of half-strength modified Hoagland's nutrient solution (9) was applied as required (Table 1). The amount of solution added was not sufficient to cause leaching.

TABLE 1—Nutrient solution composition used

Chemical	Milliequivalents per liter					
KCl		1	2	3	4	5
KH_2PO_4	1	1				1
$NH_4H_2PO_4$			1	1	1	
KNO_3	5	4	4	3	2	
NH_4NO_3		0.5		0.5	1	2.5
$Ca(NO_3)_2$	5	5	5	5	5	5
$MgSO_4$	2	2	2	2	2	2
(a)						

(*a*) Iron was supplied as "Na Fe Sequestrene" at the rate of 1 milliliter of stock solution per liter, the stock solution containing 42 grams chelated iron per liter. Other minor elements were supplied as prescribed by Hoagland and Arnon (9).

On April 1, all pots were thinned to one plant per pot; full-strength solutions were subsequently used. The total amount of solutions used was equivalent to 15 liters of full-strength solution per pot.

Each replicate consisted of the six levels of chloride on each of the two soil types, or 12 pots per species. Each treatment was replicated four times, effecting a randomized block design.

The experiment was terminated on May 11, when the stocks were ready for harvest and the sweet peas just beginning to bloom. Measurements were made on fresh weight of the above-ground portions, total length, number of leaves, and the number of flowers for both species; and in addition, stem diameters were recorded for stock. The plants were dried, and the dry weights were recorded. The plant tops were then ground to pass a 20-mesh screen. Chloride content of the dried plant tissue was measured by a modification of Samson's technique (18).

RESULTS

About April 15, differences in the growth of the sweet peas became apparent. Those grown on Granby sandy loam showed less branch-

ing and linear growth. No differences were observed on the flowering stock.

About 1 week later, spots were observed in interveinal areas of the lower leaves of some sweet peas and flowering stock. The original appearance was that of water-soaked areas, but these rapidly became necrotic. The size of each spot did not change with time, but the number of such areas did increase. The leaves on the left of Figs. 1 and 2 show the symptoms observed.

Fig. 1. Appearance of leaves of stock. Left: interveinal necrotic areas. Right: tip necrosis.

Injured leaves occurred sporadically on the sweet peas. A significantly greater percentage of injured leaves of flowering stock appeared on the three higher chloride levels than on the three lower levels. The other injured leaf which appears to the right in Fig. 1 is representative of a tip necrosis found on some of the flowering stock. This injury was correlated with the chloride level of the applied solution, the correlation coefficient being +0.863. Its occurrence was more prevalent on the Brookston soil than on the Granby soil.

Fig. 2. Appearance of leaves of sweet pea. Left: interveinal necrotic areas.

Fig. 3 shows the growth of sweet peas at 1, 3 and 5 milliequivalents per liter of added chloride. Plant growth seemed to be independent of chloride level applied; however, plants grown on Brookston clay loam appeared more dense than those grown on Granby sandy

Fig. 3. Appearance of sweet pea at the end of the experiment. Left to right: 1, 3, and 5 milliequivalents per liter of added chloride. Left: plants grown on Brookston clay loam. Right: plants grown on Granby sandy loam.

loam. This difference was due to the greater number of branches that developed on the plants grown on the Brookston soil.

Table 2 shows no growth differences which may be attributed to the chloride level applied. Growth differences due to soil type were significant at the 1 percent level, with more growth on the Brookston soil. The only real difference appeared to be the number of stems per plant. A recalculation of the data on a "per branch" basis showed that the differences due to soil type vanished. Thus, the extent of branching is dependent on soil type, and other characteristics are dependent on the number of branches produced.

TABLE 2—Growth of sweet peas as related to chloride concentration of the growing medium

	Measurement						
	Fresh weight (grams)	Dry weight (grams)	No. of branches	No. of flower buds	No. of leaves	Total length (cm.)	Internode length (cm.)
Brookston clay loam (M.E. Cl-/liter)							
0	80.5	11.5	5.8	37.5	86.8	418.3	19.2
1	86.5	13.4	6.0	36.5	89.3	464.8	21.0
2	78.8	11.5	5.5	28.3	83.8	449.3	20.9
3	63.9	8.8	5.3	26.0	73.5	388.5	21.2
4	82.1	12.0	5.0	35.5	75.0	407.0	21.6
5	75.3	10.4	5.0	25.5	71.5	373.3	20.9
Granby sandy loam (M.E. Cl-/liter)							
0	31.3	5.3	2.5	18.0	38.8	176.0	18.1
1	46.5	7.3	3.8	18.0	47.5	224.8	19.0
2	34.6	5.4	3.8	11.0	42.3	203.0	18.7
3	42.0	6.6	2.8	26.8	44.0	208.3	18.7
4	40.6	6.3	3.0	17.3	39.0	176.3	17.9
5	46.5	7.3	2.8	22.0	47.5	224.5	18.6
Significant differences							
Soils	1%	1%	1%	1%	1%	1%	1%
Solutions	N.S. (a)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction (Soil x solution)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

(a) Not significant.

Fig. 4 shows the growth of flowering stock at 1, 3, and 5 milliequivalents of added chloride on Brookston clay loam and Granby sandy loam. No growth differences were visually apparent. The only differences found were between fresh and dry weight and stem diameter of the plants grown on the two soil types (Table 3).

Fig. 4. Appearance of flowering stock at the end of the experiment. Left to right: 1, 3, and 5 milliequivalents per liter of added chloride. Left: plants grown on Brookston clay loam. Right: plants grown on Granby sandy loam.

TABLE 3—Growth of flowering stock as related to the chloride concentration of the growing medium

	Measurement						
	Fresh weight (grams)	Dry weight (grams)	Length to top leaf (cm.)	No. of open flowers	No. of leaves	Stem diameter (cm.)	Mean internode length
Brookston clay loam (M.E. Cl-/liter)							
0	102.3	12.8	42.7	9.5	24.3	9.5	1.9
1	96.9	12.4	39.3	11.3	24.8	10.0	1.6
2	105.3	12.9	44.5	9.3	24.5	9.3	1.8
3	94.9	12.3	43.7	11.3	24.0	10.1	1.8
4	98.4	12.1	42.6	10.3	25.3	9.6	1.7
5	111.6	13.4	43.4	10.8	24.5	10.4	1.8
Granby sandy loam (M.E. Cl-/liter)							
0	87.8	11.6	42.7	10.0	25.0	9.4	1.7
1	93.0	11.9	42.5	9.5	25.5	9.4	1.7
2	76.8	10.9	45.7	10.5	25.8	9.0	1.8
3	80.6	10.3	39.9	10.0	23.8	8.7	1.7
4	74.3	10.1	38.4	10.3	26.0	8.8	1.5
5	82.5	11.1	42.1	9.0	25.8	9.1	1.6
Significant differences							
Soil	1%	5%	N.S.	N.S.	N.S.	1%	N.S.
Solutions	N.S. (*a*)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Interaction (Soil x solution)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

(*a*) Not significant.

The difference in dry weight and part of the fresh weight difference is accounted for in terms of stem diameter, and not in terms of leaf number or stem length. Chloride addition had no significant effect on earliness (number of open flowers), fresh weight, dry weight, or other characteristics.

DISCUSSION

This study indicated that the spring-flowering Cuthbertson strain of sweet pea and the nonbranching Lilac-lavender variety of flowering stock did not show any reduction in growth or quality due to additions of the chloride ion up to a concentration of 5 milliequivalents per liter (177.5 p.p.m.). Visual signs appeared more often on the leaves of flowering stock grown at higher chloride levels and appeared sporadically on the leaves of sweet pea.

Growth remained unaffected by added chloride. Evidently, these species are tolerant of the chloride ion, at least up to the concentration used. Flowering stock is reported to be moderately tolerant of high salt concentrations (14). Although the present study is of a different nature, the possibility of a relationship between salt tolerance and chloride ion tolerance is suggested.

The more important difference found in plant growth was a reduction of branching of sweet peas grown on Granby sandy loam. Two major differences, pH and aeration, exist between the soil types. Post (15) states that the best pH range for sweet pea growth is between pH 6.0 and 7.5. The pH of the Granby soil was 8.0.

Workers (3, 13, 15, 20) agree that sweet pea soil should be well drained to a considerable depth; however, this condition did not exist in the Granby soil. Inhibition of branching could not have been due to a low level of potassium, as this ion is in greater abundance in Granby sandy loam. Drainage and/or pH or other factors may have caused the observed reduction in branching.

Both fresh weight and dry weight of flowering stock were significantly less in Granby sandy loam. This was found to be due, in part, to a reduction in stem diameter. Fresh weight differences were greater and were not as largely dependent on stem diameter. This evidence indicates that water uptake by flowering stock grown on Granby sandy loam was inhibited. This may have resulted in a reduction in cell enlargement. The restriction of aeration in this soil may have been the causal factor.

Visual signs which appeared on some lower leaves of both plant species were not similar to those reported by most authors (1, 2, 4, 7), but resembled those found by Dilley (6) on grape and peach when irrigated with 315 p.p.m. of chloride and 624 p.p.m. of sulfate.

The injury seen in the leaf of flowering stock at the right of Fig. 1 is similar to that described by Baker et al. (2) who noted tiny, yellow-brown necrotic spots at the leaf tip caused by a local high concentration of soluble salts at the hydathodes. This may be an early condition of signs reported by other workers. Although growth of plants was not reduced, it is possible that leaf signs were due to toxic levels of chloride, as the ion may concentrate in the leaf blades (4, 12, 19).

SUMMARY

The specific influence of the chloride ion on the growth of sweet pea and flowering stock was studied. The plants were grown on Brookston clay loam and Granby sandy loam, soils similar to those used in commercial greenhouses. A random block design was employed, using six levels of chloride, each replicated four times. The solution composition, in other respects, was similar to that outlined by Hoagland and Arnon (9).

Growth was measured as fresh weight, dry weight and number of leaves for both plants. Additional measurements were made of the number of branches and flower buds on sweet pea, and number of open flowers, stem diameter, and mean internode length of flowering stock. Chloride determinations were made on the dried plant tissue.

On neither plant were significant reductions in growth noted which were due to the application of the chloride ion.

Interveinal necrotic areas were found to be more prevalent on the leaves of flowering stock grown at the three higher levels of chloride than at the three lower levels. This injury appeared sporadically on some of the lower leaves of sweet peas. A foliar tip necrosis was displayed by flowering stock. Its incidence correlated closely with the amount of chloride applied in the nutrient solution.

Granby sandy loam severely inhibited the branching of sweet pea. The cause is unknown, although it may have been due to restricted drainage and aeration, too high a pH, or a combination of both factors.

Granby sandy loam was found to reduce stem diameter of flowering stock. Restricted aeration may have inhibited water uptake and, thus, cell enlargement.

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PUMPKIN BLACK ROT IN MICHIGAN, 1956

By D. J. deZEEUW and H. S. POTTER[1]

DURING NOVEMBER 1956, an unusual number of complaints of rotting pumpkins were received from Wayne County, Michigan. Losses as high as 75 percent (grower and retailer combined) were reported on one crop of 110 tons.

The first symptoms of the rot were small, firm, greyish spots on the fruit. As the spots enlarged, they became black and sooty from formation of stromatal tissue by the invading fungus. Superficially, the rot resembles soft rot, but it is neither odoriferous nor typically a wet rot. The fungus penetrates the inner fruit tissue and eventually causes the outer walls to collapse. Fruit breakdown occurs very rapidly at warmer storage temperatures.

Isolations from affected fruits showed the disease to be black rot caused by *Mycosphaerella melonis* (Pass.). Chiu, and Walker. The pycnidia, pynospores, spore discharge, and symptomolgy agree with the descriptions for the fungus in the literature.[2] Subsequent inoculations of pumpkin fruits have verified the pathogenicity in this stage of plant development.

INOCULATION OF FRUITS

Agar block cultures approximately 1 cm. square were used in the inoculations. The fruits were washed, swabbed with alcohol, and dried. The inoculum was then applied to wounded and unwounded areas, and the site was covered with damp absorbant cotton and a plastic patch held in place with cellophane tape (Fig. 1).

A few natural infections of the fruits occurred, but generally the infection site coincided precisely enough with the inoculum used

[1]Associate professor, department of botany and plant pathology; and Extension plant pathologist, Michigan State University.

[2]Chiu, W. F., and J. C. Walker (1949 a). Morphology and variability of the cucurbit black rot fungus. Journal Agr. Res. 78: 81-102.———————(1949 b). Physiology and pathogenicity of the cucurbit black rot fungus. Jour. Agr. Res. 78: 589-615. Grossenbacher, J. G. (1909). A Mycosphaerella wilt of melons. N. Y. (Geneva) Agr. Expt. Sta. Tech. Bul. 9: 193-229. Wiant, J. S. (1945). Mycosphaerella black rot of cucurbits. Jour. Agr. Res. 71: 193-213.

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Fig. 1. Pumpkin black rot inoculation, showing the moist cotton patch held on infection site by cellophane tape.

to confirm pathogenicity. The advanced margin of artificially induced infection closely resembled that produced by natural infections, and older lesions developed the typical black rot with stromatal material containing fruiting bodies of the fungus (Fig. 2.).

Reisolation of the fungus from decayed areas near inoculation sites gave pure cultures that were macroscopically indistinguishable from the original cultures. From this trial (Table 1), it was apparent that wounds either aided invasion or were essential for rapid establishment of the fungus. Some injury could not be avoided in handling the fruit; consequently, infections in "unwounded" areas very probably occurred through undetected small wounds.

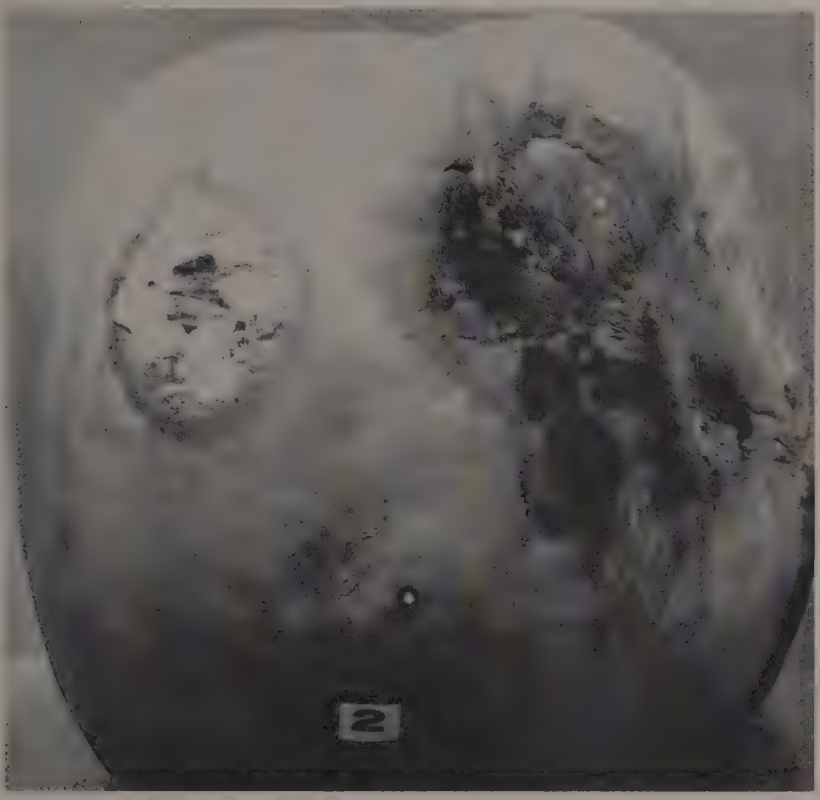

Fig. 2. Pumpkin black rot inoculation. Left side, artificial infection; right, an older natural infection. Note similarity of the advanced margin of rot around both infections and the black stromatic areas in the older lesion.

TABLE 1—Effect of wounding on the incidence of black rot of pumpkin fruits caused by Mycosphaerella melonis on pumpkin fruits

Inoculum (*a*)	Wounds	Fruit		
		1	2	3
M. melonis	none	rot	no rot	no rot
M. melonis	cuts	rot	rot	rot
None	none	no rot	no rot	no rot
None	cuts	no rot	no rot	no rot
M. melonis	cuts	rot	.....	.....
M. melonis	none	rot	.....	.....
M. melonis	punctures	rot	.....	.....
M. melonis	none	rot	.....	.....
None	cuts	no rot	.....	.....
None	punctures	no rot	.....	.....
None	none	no rot	.....	.....

(a) Agar block cultures 1 cm. square.

A second inoculation trial was made in November to determine the effect of wounding and certain fungicide cover sprays on infection by the fungus. Twenty-five fruits were used, five for each fungicide treatment. Each fruit was numbered and marked with ink into three sectors: one for a wounded and inoculated locus, the second for non-wounded and inoculated, and a third for the noninoculated control. All wounds consisted of three parallel cuts, approximately 1 mm. deep and 1 cm. long, made with a clean scalpel.

After wounding, the sprays were applied and allowed to dry. Inoculum, consisting of pycnospores and mycelial fragments in water, was applied to each inoculation site with an eyedropper and allowed to dry in order to retain inoculum in the site. To insure proper incubation, inoculation sites were covered with damp cotton pads held in place by plastic covers. The centers of these pads were removed, thus preventing direct contact with the inoculum.

The experiment was conducted in a greenhouse where temperatures ranged between 65° and 75° F. Infections were apparent within 7 days, and lesions were extensive at 12 days.

Fig. 3. Control of pumpkin black rot infections by fungicide cover sprays applied before artificial inoculation. 0=control; 1=Dithane Z−78; 2=Ferbam 76; 3=Phygon (Naugets); 4=Orthocide 406.

Four commercial fungicides were tested as protectants: Dithane Z-78 (65 percent zineb), Ferbam 76 (76 percent ferbam), Phygon (Naugets) (50 percent dichlone), and Orthocide 406 (50 percent captan). Spray materials were mixed at the rate of 1 pound active ingredient per 100 gallons of water. They were sprayed on the fruit to the point of runoff with a hand-sprayer. Sprays were applied after wounding, and the surface was permitted to dry before inoculation.

TABLE 2—The effect of several fungicidal sprays on the control of black rot of pumpkin fruits

Treatment	Fruit No.				
	1	2	3	4	5
Dithane Z-78 (*a*)					
Wounded fruits	no rot	no rot	no rot	no rot	rot (*c*)
Nonwounded	no rot	no rot	no rot	no rot	no rot
Ferbam 76					
Wounded	rot (*b*)	rot (*b*)	no rot	no rot	no rot
Nonwounded	no rot	no rot	no rot	no rot	no rot
Phygon Naugets					
Wounded	no rot	no rot	no rot	no rot	no rot
Nonwounded	no rot	no rot	no rot	no rot	no rot
Orthocide 406					
Wounded	rot	rot (*b*)	no rot	rot	rot (*b*)
Nonwounded	no rot	no rot	no rot	no rot	no rot
Control—no spray					
Wounded	rot	rot	rot	rot	rot (*b*)
Nonwounded	rot	rot	rot (*c*)	no rot	no rot

(*a*) All fungicides used at rate of 1 pound per 100 gallons (active ingredient).
(*b*) Infection slow starting. None of the noninoculated controls on sprayed fruits developed disease.
(*c*) Probably from natural infection of fruit.

These tests showed good protection against black rot by all compounds except Orthocide 406. Phygon (Naugets) and Dithane Z-78 appeared to be somewhat more effective than Ferbam-76 (Fig. 3 and Table 2). In the case of Orthocide, it is probable that it too would have given good protection if applied at a higher concentration or if less severe inoculation methods were used. Again, wounds appeared to be important in establishing infection, as shown by the lower incidence in unsprayed nonwounded fruits as well as in the nonwounded Orthocide-sprayed fruits.

DISCUSSION

In commercial practice, harvesting the pumpkins for Halloween sale consists of removing the fruits from the field and piling them in a central location before marketing. The storage period varies from a few days to several weeks. During the autumn of 1956, much of the fruit was held for several weeks at mild temperatures. Enough moisture was present so that many fruits became infected and rot developed rapidly after harvest. The losses were greater than usual in 1956 because weather cold enough to retard rot was delayed.

Since inoculum of the fungus is undoubtedly present in most years even though the vines may not be attacked severely, the possibility of epidemic threatens each warm harvest season. The preliminary spray trials in the greenhouse indicate that a protective cover spray of the fruits before harvest or at harvest should reduce the amount of infected fruits substantially. Because wounds appear to be significant in the establishment of infection, the fruits should also be handled carefully in order to minimize cuts, scratches, and bruises.

MICHIGAN BROILER TEST NO. 6 SUMMER 1957[1]

By J. A. DAVIDSON, W. N. FISCHER, and H. C. ZINDEL

Department of Poultry Husbandry and W. K. Kellogg Farm

PURPOSE OF TEST

This was a descriptive test of varieties, strains, and strain crosses under environment and management conditions at the W. K. Kellogg Farm, Hickory Corners, Michigan.

CONDITIONS OF TEST

The test was conducted on the ground floor of the two-story brooder house at Michigan State University's Kellogg Farm. Birds were entered on July 11, 1957. One hundred and four chicks (52 pullets and 52 cockerels) were required for an entry (Table 1). Each entry was placed in a pen of equal floor space (about 1 square foot per bird) which had been drawn by lot. Each chick was wing-banded

[1]Sponsored by the Michigan State Poultry Improvement Association.

TABLE 1—Entrants and breeding groups

Pen No.	Breeder	Male	Female
2	Lambright Hatchery, LaGrange, Ind.	White Meateor	Arbor Acres
3	Weaver's Hatchery, Inc., Wakarusa, Ind.	Vantress	Arbor Acres
4	Sterling Hatchery, Sterling, Mich.	Vantress	EE101 X EE100
7	DeWitt's Zeeland Hatchery, Inc., Zeeland, Mich.	Special Cross	
8	DeWitt's Zeeland Hatchery, Inc., Zeeland, Mich.	X-234	
9	Cobb's Pedigreed Chicks, Inc., Concord, Mass.	White Rock	White Rock

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for identification in order that a sample for the slaughtering data could be drawn.

Chicks were debeaked before placing them in the pen; they were confined to a smaller area by a tight, solid corral for 2 days. Heat lamps were turned out during the day after the chicks were 4 weeks old, but they were turned on at night when outside temperatures indicated a need.

Chicks were fed from a small feeder placed on paper. The paper was removed the second day. Large feeders were substituted for smaller feeders as the chicks grew. All feeders were the same type for each pen. Small fountains were used until the chicks were large enough to use automatic waterers. Sugarcane litter was used in the beginning of the test. Shavings and straw were added later.

DISEASE CONTROL

A coccidiostat (Nicarbazin) in the feed was used at recommended levels throughout the test. At 10 days, the chicks were given bronchitis vaccine in the water. At 3 weeks, the chicks were given Newcastle disease vaccine in the water.

WEIGHING AND SCORING

At 4 weeks and 6 weeks, each entry was group weighed. At 8 weeks, the birds were individually weighed. The average live weight, feed consumed, and number of birds are shown in Table 2.

At 10 weeks of age, the birds were individually weighed and checked for sex; and a random sample of 10 of each sex was taken

TABLE 2—Feed conversion and weights at 4, 6, and 8 weeks

Pen No.	4 weeks			6 weeks			8 weeks		
	Number died	Average wt. (lb.)	Feed per pound of chicken	Number died	Average wt. (lb.)	Feed per pound of chicken	Number died	Average wt. (lb.)	Feed per pound of chicken
2	1	.82	1.93	1	1.58	2.19	1	2.3	2.50
3	0	1.02	1.70	1	1.90	1.91	1	2.6	2.31
4	0	.85	2.36	0	1.58	2.35	1	2.3	2.51
7	0	.84	1.86	1	1.60	2.08	2	2.3	2.36
8	1	.85	1.85	1	1.63	2.07	1	2.2	2.42
9	3	1.10	1.83	3	2.04	2.03	4	2.9	2.29
Total or Av.....	5	.92	1.91	7	1.72	2.09	10	2.4	2.39

TABLE 3—Feed conversion and mortality—10 weeks

Pen No.	Mortality	Pounds of chicken per 100 pounds of feed	Feed per pound of chicken	Number	
				Males	Females
	(percent)	(lb.)	(lb.)		
2	3.00	36.45	2.74	48	49
3	3.80	38.43	2.60	52	49
4	.95	37.45	2.67	51	53
7	5.50	37.85	2.64	49	53
8	1.83	38.87	2.57	53	54
9	5.50	39.10	2.56	50	52
Total or Av....	3.46	38.09	2.63	303	310

for slaughtering (Tables 3 and 4). The variability for each group and sex was determined.

The samples were mixed in pens where they remained overnight. They were loaded the next morning—20 in a crate—and transported to the dressing plant of the Hamilton Farm Bureau, Hamilton, Michigan. There, live weights were taken as they were placed on the

TABLE 4—Live weight and variability of each sex—10 weeks—entire group

Pen No.	Males		Females	
	Av. wt.	Variability (*a*)	Av. wt.	Variability (*a*)
	(lb.)		(lb.)	
2	3.5	10.1	2.7	14.8
3	4.0	7.9	3.1	9.3
4	3.6	8.9	2.8	9.0
7	3.7	10.0	2.8	10.0
8	3.5	10.2	2.8	13.6
9	4.4	9.7	3.5	9.2
Av. ..	3.8	....	2.9	....

(*a*) Expressed as coefficient of variation. A low numerical value of the coefficient shows greater uniformity.

dressing line. The eviscerated weights were recorded (Table 5). The birds were scored for carcass quality after evisceration (Table 6).

TABLE 5—Live and eviscerated weights of samples and carcass yields—10 weeks

Pen No.	Live		Drawn		Carcass yields	
	Male	Female	Male	Female	Male	Female
	(lb.)	(lb.)	(lb.)	(lb.)	(percent of live weight)	
2	3.5	2.5	2.6	1.86	74.01	75.30
3	4.07	3.0	3.05	2.27	74.93	75.66
4	3.64	2.76	2.7	2.14	74.17	77.53
7	3.80	2.76	2.85	2.16	74.60	78.31
8	3.66	2.54	2.76	1.92	75.40	75.59
9	4.49	3.52	3.32	2.61	73.94	74.14
Av.....	3.87	2.84	2.88	2.16	73.49	74.90

TABLE 6—Dressed score of samples — 10 weeks (a)

Pen No.	CARCASS GRADE (b)										
	Fleshing		Feathering		Fat		Conformation		Defects (c)		Percent grade "A"
	M	F	M	F	M	F	M	F	M	F	
2	1.7	2.35	1.1	1.0	1.4	1.85	1.1	1.6	1.1	1.6	50
3	1.3	1.95	1.0	1.0	1.35	1.4	1.1	1.05	1.25	1.1	65
4	1.75	1.9	1.05	1.2	1.45	1.7	1.25	1.1	1.45	1.2	30
7	1.4	2.1	1.15	1.16	1.25	1.6	1.0	1.33	1.35	1.0	42
8	1.5	2.4	1.2	1.1	1.25	1.65	1.1	1.4	1.35	1.1	45
9	1.4	1.55	1.05	1.0	1.2	1.05	1.05	1.1	1.75	1.1	50
Av.....	1.5	2.0	1.09	1.05	1.33	1.51	1.1	1.24	1.37	1.16	...

(a) The authors express appreciation to Dr. L. E. Dawson, associate professor of poultry, for assistance in scoring and grading of eviscerated carcasses.
(b) Dressed score: 1, 2, 3, 4, 5. Based on Federal Standards of Quality; average score shown.
(c) Defects: Includes breast blisters, crooked and dented breastbones, crooked backs, etc.

FEED

The chicks were fed a commercial broiler-starter until they were 6 weeks old. A broiler-finisher was used for the balance of the test[2]. The guaranteed analysis of the starter was crude protein, minimum 22 percent; crude fat, minimum 3.5 percent; and crude fiber, maximum 3.5 percent. The finisher was guaranteed to contain 19 percent protein, 3.5 percent fat, and not over 3.5 percent fiber.

[2]The feed for this sixth test was manufactured by the Michigan Farm Bureau Services of Lansing, Michigan. This feed company had been selected by lot from four feed mills operating in Michigan who indicated that they could supply a starter in crumble form.

LIMITATIONS

Results from such samples should not be interpreted competitively by entrants.

Relatively little reliance should be placed on information from only one test. Repeated testing will be required to reliably evaluate real performance of strains and strain crosses. It is hoped this attitude will be expressed by the entrants in using these data for other than their own information. A winner cannot be picked because of the problem of fairly evaluating the various characteristics which were observed.

PURE STRAIN AND STRAIN-CROSS PERFORMANCE AT TWO DIFFERENT LOCATIONS

By L. R. CHAMPION

DEPARTMENT OF POULTRY HUSBANDRY

FROM OCTOBER 1956 to August 1957, data were collected at Michigan State University and at the M. S. U. Kellogg Farm, Hickory Corners, Michigan, on the performance of two pure strains of S. C. White Leghorns and their reciprocal crosses.

For identification purposes, the pure strains are hereafter referred to as Strain 1 and Strain 2. The reciprocal strain-cross chicks are designated as X-12 and X-21. In explanation of the symbolic and numerical designations, chicks of X-12 breeding were strain crosses produced by Strain 1 males mated to Strain 2 females, and chicks of X-21 breeding were strain crosses produced by Strain 2 males mated to Strain 1 females.

The object of this test was to compare the performance of full and half-sisters, under more or less field conditions, at the M. S. U. Kellogg Farm with the performance of full and half-sisters at the home station.

MATERIALS AND METHODS

Pedigreed pure strain and reciprocal strain-cross chicks were hatched from eggs produced by parental stocks which have been bred as a closed flock at this experiment station since 1952. The hatching season extended over a period of 10 weeks during March, April, and May. All chicks, produced by individuals in single male matings, were hatched at M. S. U. and were brooded and reared intermingled.

It is realized that from a precision standpoint, a more critical mating system involving the simultaneous production of both pure strain and strain-cross chicks would have been highly desirable. However, this procedure could not be followed.

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At about 10 weeks of age, the sexed pullet chicks were placed on range and vaccinated for fowl pox. At 14 weeks of age, the pullets received an intramuscular vaccination of killed Newcastle vaccine. During the first 2 weeks of September, the pullets were sorted, debeaked, and legbanded.

M. S. U. Kellogg Farm—The following numbers and kinds of pullets were trucked to Hickory Corners: 75 Strain 1, 75 Strain 2, 150 X-12, and 150 X-21 pullets. Three hundred of the pullets, intermingled with respect to populations, were housed in a 20- by 42-foot pen; 150 were housed in an adjacent half-pen. After housing, the pullets were given an attenuated Newcastle and bronchitis vaccine in the drinking water.

During this experiment, the females were fed a 20-percent protein commercial breeding mash *ad libitum,* supplemented with restricted feeding of corn, wheat, and oats. The grain was apportioned so that the average daily flock intake of grain was about two-thirds that of the mash consumption.

A deep litter system of management was employed. Artificial lights provided for a 14-hour light day. The females were trapnested 3 consecutive days per week for a period of 10 months, October 1—July 31. Body weights were taken in January, and a minimum of four egg weights per layer was taken in March. Egg production was calculated on a hen-day basis.

Poultry Plant, M. S. U.—Seventy-five Strain 1, 195 Strain 2, 25 X-12, and 50 X-21 pullets were placed in 8- by 12-foot single male breeding pens. The females were fed a commercial all-mash breeding ration *ad libitum,* and received a 14-hour light day. Deep litter was used. Trapnesting was on a 7-day per week schedule for 263 days. Body weights were taken in January, and a minimum of six egg weights per layer was obtained in March.

RESULTS AND DISCUSSION

Data on the performance of the pure strain and strain-cross females at the two locations are presented in Table 1. With one exception, the egg production of the females at M. S. U. was better than the egg production of the females at the M. S. U. Kellogg Farm. The strain-cross females laid equally well at both locations. Mortality in all populations at the Kellogg Farm was greater than that of the females at the home experiment station.

TABLE 1—Performance data on pure strain and strain-cross S. C. White Leghorns at two locations

	Strain 1		Strain 2		Strain-cross X-12		Strain-cross X-21	
	Kellogg	M.S.U.	Kellogg	M.S.U.	Kellogg	M.S.U.	Kellogg	M.S.U.
No. of females	65	73	69	193	146	25	141	47
No. hen-days	16,097	15,945	16,381	43,577	38,316	5,341	35,097	10,623
Production (percent) (*a*)	57.58	69.68	49.87	62.41	76.67	76.91	67.12	77.51
Eggs /♀/ 365 days	210.17	254.33	182.03	227.80	279.85	280.72	249.99	282.91
Mortality (percent)	36.92	10.34	27.54	19.17	23.29	16.00	29.78	17.02
Av. body wt. (lb.)	4.35	4.15	3.73	3.86	3.67	3.75	4.03	4.00
No. egg wts.	182	300	156	625	421	121	374	222
Av. egg wt. (gm.)	62.5	59.5	58.0	57.2	59.4	57.64	60.1	57.65

(*a*) 304 days, 3-day trap at M.S.U. Kellogg Farm; 263 days, 7-day trap at Poultry Plant, M.S.U.

One possible explanation for the higher mortality at the M. S. U. Kellogg Farm is that an epizootic was prevalent in this flock during December and January, as shown by respiratory difficulties observed. This may, in part, also account for a less intense rate of egg production by the females at the M. S. U. Kellogg Farm. Lingering morbidity, resulting in failure to lay over an extended period of time prior to death, is commonly observed under these conditions. However, the X-12 strain-cross females evidently better withstood the epizootic agent(s) than did the other stocks if the high level of egg production and lower mortality are appropriate criteria. The over-all average superiority of the strain-cross females with respect to egg production is self-evident. Differences in body weight and egg weight are presented.

It has been recognized that the genetic endowment of full sisters and that of half-sisters is not necessarily equal. However, the use thereof at the two locations should materially reduce that portion of the genetic variance contributing to differences in performance.

SUMMARY

Full and half-sisters from two pure strains of S. C. White Leghorns and crosses involving them were housed at the M. S. U. Kellogg Farm, Hickory Corners, Michigan and at the Poultry Plant, Michigan State University. Data on hen-day egg production, mortality, egg weight, and body size are presented.

Differences in egg production and mortality were of a large magnitude. These data indicate that the strain-cross females were superior to the pure strain females with respect to egg production at both locations.

CONTROLLING MUMMY BERRY DISEASE OF BLUEBERRIES BY SOIL TREATMENT

By ROBERT H. FULTON

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

MUMMY BERRY, *Monilinia Vaccinii-corymbosi*[1], is still considered the most important fungus disease of the cultivated high bush blueberry in Michigan. The disease is initiated early in the spring, as the plants are breaking dormancy, by the formation of little cuplike mushrooms (apothecia) on the fallen mummied berries. These miniature, inconspicuous mushrooms discharge spores that are carried upward by air currents into the bushes, causing shoot infection and subsequent infections to the blossoms and young fruit (Fig. 1).

The fungus can be reestablished on the bushes only by means of these spores. If the mushrooms could be killed by a chemical

[1]Honey, E. E. (1936). North American species of Monilinia. I. Occurrence, grouping and life histories. Amer. Jour. Bot. 23: 100-106.

Fig. 1. Apothecia arising from mummied berries infected the previous season.

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spray or dust on the ground, the fungus would not become established in the bushes.

A previous investigation by Fulton and Grigsby[2] showed that chemical sprays or dusts applied on the soil beneath the bushes accomplished remarkable control. However, more information was needed on timing of applications and plant injury, as related to concentration and soil type.

HISTORICAL SURVEY

All of the earlier investigations prior to and including 1952 indicated that control of mummy berry was possible and that apothecial eradication to eliminate the primary inoculum showed the most promise.[3]

Recently in New Jersey, Varney[4] showed that two or three weekly sprays of protectant fungicides beginning at bud break gave good control of the blossom blight phase. He further reported that a high degree of apothecial control was obtained with calcium cyanamid, Elgetol, and Premerge when used as an eradicant ground treatment. This simulated our previous results.

No phytotoxicity was noted with calcium cyanamid, neither granular or dust form, when used as high as 400 pounds per acre, or with Elgetol or Premerge at various concentrations applied at 500 gallons per acre.

EXPERIMENTAL RESULTS

Shoot Blight Phase

The blueberry plantation where most of the tests were conducted had a past history of severe mummy berry. The site was well-drained so that early treatments, even during wet conditions, were feasible. The soil type was acid muck.

In 1953, soil treatments and foliar sprays were evaluated alone and in combination for control of the shoot blight phase of the disease. The individual plots consisted of four adjacent rows, eight bushes per row, with four randomized replications.

[2]Fulton, R. H., and B. H. Grigsby (1952). The effect of several soil treatments on mummy berry disease of blueberries in Michigan. Mich. Agr. Expt. Sta. Quart. Bul. 34: 297-302.

[3]Fulton and Grigsby. Op. cit.

[4]Varney, E. H. (1954). Protectant sprays and eradicant ground treatments for control of mummy berry of blueberry, 1954. 23rd Annual Blueberry Open House. New Jersey Agr. Expt. Sta. Also see Varney, E. H. 1955. Protectant sprays and eradicant ground treatments for control of mummy berry of blueberry, 1955. 24th Annual Blueberry Open House. New Jersey Agr. Expt. Sta.

The soil treatment plots received one application when apothecia were present but the buds on the bushes had not as yet opened. The material Aero calcium cyanamid (57 percent), special grade, was applied at 100 pounds per acre with a power duster. In addition, Aero cyanamid soluable (85 percent monosodium cyanamide) was sprayed on the soil thoroughly at a rate of 17.5 pounds per acre.[5]

The foliar spray plots received three applications, beginning with bud break, at about 10-day intervals. The two materials tested were Captan[6] and Zineb (Dithane Z-78)[7], both at a dosage rate of 2 pounds per 100 gallons of spray. These fungicides were applied at a rate that gave thorough wetting of the plant surfaces without excessive runoff.

The data on total shoot blight were obtained from the four center bushes on each of the two inside rows of each plot. The results are presented in Table 1.

TABLE 1—Control of the shoot blight phase of mummy berry

Materials		Shoot blight per bush (Av.)	Disease Reduction
Soil treatment	Foliage sprays		Percent
Calcium cyanamid	none	13.0	43.48
Calcium cyanamid	Captan	11.5	50.00
Calcium cyanamid	Zineb	10.0	56.52
Sodium cyanamid	none	9.5	58.70
Sodium cyanamid	Captan	8.0	65.22
Sodium cyanamid	Zineb	4.5	80.44
None	Captan	17.5	23.91
None	Zineb	15.5	32.61
Check		23.0	0.00

As shown in Table 1, eradicant soil treatments with calcium cyanamid reduced the shoot blight phase 44 percent. When using sodium cyanamid, a material no longer available from commerical sources, reduce it 59 percent. When used in combination with soil treatments, Zineb gave better control than Captan. However, foliar treatments alone without eradicant soil treatments failed to give adequate control. No plant injury was observed in any of the plots.

[5]Both materials are proprietary products of the American Cyanamid Company.
[6]A proprietary product of the Stauffer Chemical Company.
[7]A proprietary product of the Rohm and Haas Company.

An analysis of these results and a consideration of the problem favors soil treatments. Soil treatments alone gave considerable control; dusting equipment required is light; and application is easier, quicker, and cheaper than sprays. Foliage sprays alone were inadequate; even in combination with soil treatments, they did not appear justified. Sprays require costly, heavy equipment that is difficult to move through the blueberry plantation during the wet spring periods.

Timing of Soil Treatments

As far as known, all previous eradicant soil treatments were delayed until the apothecial fructifications were present. In some instances this is impractical: poor soil conditions or flooding from excessive rains prevent access to the plantation with machinery; or early sprouting blueberry varieties may be injured by the strong chemical eradicants. It was desired to determine whether earlier applications would give significant control.

April 15 is the average date of first appearance of apothecia in Michigan plantings. An early application was made on April 10. This was compared with an application on April 18 when apothecia were present at a rate of four per square foot. Counting the number of apothecia present on April 22 gave the comparison between treatments.

The data are presented in Table 2.

TABLE 2—Effect of timing calcium cyanamid soil treatments with apothecial emergence

Rate per acre	Time of application	Apothecia present per square foot (*a*)	Percent control
100 lb.	Pre-emergence	16.1	77.92
200 lb.	Pre-emergence	5.8	92.04
300 lb.	Pre-emergence	4.2	94.24
100 lb.	Post-emergence	2.4	96.71
200 lb.	Post-emergence	0.4	99.45
300 lb.	Post-emergence	0.0	100.0
Check		72.9	.....

(*a*) Average of four replications.

As shown in Table 2, the pre-emergence treatment failed to give adequate control, even at the highest rate of application. Even a few undestroyed apothecia can reinfect twigs and cause a large-scale

development of mummy berry. Thus, soil treatment must prevent *all* the apothecia from developing to maturity and discharging their spores.

As further indicated in Table 2, the post-emergence treatment was more effective at all rates, particularly at the 200- and 300-pound levels.

Methods of Application

In conjunction with the other tests, large-scale field trials using two methods of application were evaluated in several fields of the Jersey variety. In one, the Aero calcium cyanamid material was applied by a Caterpillar-drawn power duster; in the other, it was applied by a commercial airplane duster. In both trials, 100- and 200-pound per acre dosages were used.

Apothecia were present in small numbers at the time of application. The bushes were heavy with dew, causing greater adhesion of the caustic cyanamid dust, but the buds had not broken and no apparent injury resulted to the bushes.

Results were determined by first counting the number of blighted shoots and later the resulting number of worthless mummied berries. The counts presented in Table 3 were made from 100 bushes selected at random under each treatment.

TABLE 3—A comparison of ground and airplane dusting equipment on the control of primary shoot blight and the secondary infected fruit stage of the mummy berry disease, using Aero calcium Cyanamid

Method of application	Rate/acre	Shoots blighted per bush (av.)	Infected fruit (*a*) per bush (av.)
Land-drawn duster	100 lb.	9.54	5.32
Airplane duster	100 lb.	8.72	7.84
Land-drawn duster	200 lb.	3.03	1.46
Airplane duster	200 lb.	3.32	2.56
Check		27.60	12.08

(*a*) Average of the total number of shoots blighted and infected berries on 100 bushes per treatment.

Table 3 shows no significant difference in control between airborne and land-drawn equipment. This is important since in some seasons excessive spring rains would make airplane application the only method feasible.

These data further indicate that 200 pounds were more effective than 100 pounds per acre, and that fewer number of blighted shoots result in less mummy berry.

Phytotoxicity

In the past, the application of Aero calcium cyanamid as a spring fertilizer to cherry and peach trees has caused plant injury in several Michigan orchards. Since the possibility of plant injury was not determined in the 1951 trials, several tests were made over the succeeding years.

In one trial, Aero calcium cyanamid was used at a rate of about 175 pounds per acre on the same planting for four consecutive seasons. The soil type was muck, and the varieties within this plot were Jersey and Rubel. Soil pH determinations were made before and 1 week after each spring application with no significant change throughout the period of the trial.

Observations on shoot and blossom development during the early part of the growing season showed no visible toxicity. This was encouraging; not only was this material applied to the floor and crowns of the bushes, but being dust-like in form, it was always wafted up into the aerial portions of the dormant bushes. However, caustic materials such as Aero calcium cyanamid applied directly to sprouted buds have resulted in leaf burn.

As Michigan blueberries are grown on three acid soil types, muck, sandy loam, and peat, it was further questioned whether any of these soil types would contribute toward plant injury from Aero calcium cyanamid.

Samples of the three soil types were collected and placed in No. 10 cans with rooted cuttings of the Jersey variety for testing. Before these cuttings broke dormancy, the soil surface of lots of six cans each were treated with Aero calcium cyanamid at rates of 100, 200, 300, and 400 pounds per acre.

The cuttings were carefully observed throughout the growing season; no visible toxic effects were noted. The only significant observation was a delay in the appearance of broadleaf weeds in the 300- and 400-pound rate lots.

SUMMARY

The prevention of apothecial formation from the fallen mummified blueberries (on the ground or lodged in the low crowns of the bushes) effectively controlled the reestablishment of the fungus on young, tender shoots.

Apothecial destruction has been attempted by cultivation and hoeing. The power-driven hoes that cultivate the areas around and between the bushes has improved and reduced the cost of this practice compared to hand hoeing. However, cultivation is incomplete, because equipment cannot clean out the crowns of the bushes where many of the infected mummified fruit become lodged.

A continuation and enlargement of previous studies on apothecial destruction by chemicals is presented. It was shown that eradicant soil treatments of Aero calcium cyanamid dust were superior to protective foliar spray treatments. Better apothecial destruction was obtained when the eradicant treatment was delayed until partial emergence. The 200-pound per acre rate was adequate, and application by land-drawn equipment or by airplane was comparable.

Aero calcium cyanamid (57 percent), special grade, as used in these studies did not injure the plant or destroy the desired acidity of the soil. Further, the material appeared safe, regardless of soil type.

BEEF CALF PRODUCTION ON WILD LAND AND CULTIVATED LAND PASTURE IN NORTHERN MICHIGAN

By A. M. BERRIDGE, G. A. BRANAMAN, C. M. HARRISON, and D. WEAVER[1]

There are large acreages of cutover land in northern Michigan, varying widely in soil type, productiveness and vegetative cover. In many areas, abandoned farmland accounts for much acreage, along with areas too wet, stony, rough and unproductive to fit into a system of cultivation.

The use of these areas as grazing lands leads to many questions as to the type or kind of animals best suited to the area, and the amount of gain or production that could be expected. The acreage necessary to maintain brood cows in desirable condition and to produce good type feeder calves economically has especially demanded attention.

The popularity of beef cattle breeding herds for growing feeder cattle in the central states has greatly increased during the period of the experiment reported herein. Land and facilities became available at the Lake City Branch Experiment Station in Missaukee County, Michigan, to compare the productivity of a wild land area with improved pasture fields.

The 10-year experiment was started in June 1941 with a group of 2-year old grade Hereford heifers with their first calves. A 60-acre cutover area which included a 3-acre abandoned field was designated as the wild land grazing area. Water for the cattle was available from a small stream which flowed throughout the season.

The soil was largely of a sandy nature, but the area also contained several acres of low lying, poorly drained, slightly heavier soil. The vegetation was a mixture of Kentucky bluegrass, poverty grass and

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volunteer alsike clover as ground cover; interspersed with stumps, shrubs and trees including pin cherry, poplar, willow, sweet fern, juneberry and oak. Some scattered areas of wild white clover developed during the last 3 years.

The first 2 years of observation on the wild land pasture revealed heavy browsing on nearly all woody vegetation. Small trees were killed, and larger trees had a definite browse line. Seven plats, 10 by 10 feet, placed on seven different ground cover areas in the wild pasture, were also studied. Observations were made on these plats at the beginning of the experiment, at the end of the first and second pasture season, and at 5 and at 10 years.

No significant change occurred on these areas, except for plats IV and V. The density of Kentucky bluegrass became approximately 25 percent higher on plat IV. On plat V, the ground cover at the beginning was nearly 100 percent orange hawkweed, with a trace of Kentucky bluegrass, Canada bluegrass and wild white clover. At the end of 10 years of grazing, about 30 percent of the orange hawkweed had been replaced with wild white clover.

The carrying capacity of the wild pasture was unknown; so, as a first trial, 12 cows and a bull were turned into the pasture on June 4,

TABLE 1—Ten-year average weights and gains of Hereford cows and heifer and steer calves on control and wild land pasture at Lake City Experiment Station

	Control pasture	Wild pasture
Av. time on experimental pasture	129 days	129 days
Total number of cows	86	69
Av. cow weight in October	1,145 lb.	1,138 lb.
Av. cow gain on pasture	89 lb.	29 lb.
Total number heifer calves	43	25
Av. heifer calf weight in October	391 lb.	408 lb.
Av. heifer calf gain	236 lb.	245 lb.
Av. daily heifer gain	1.76 lb.	1.88 lb.
Total number of steer calves	43	44
Av. steer calf weight in October	410 lb.	416 lb.
Av. steer calf gain	252 lb.	255 lb.
Av. daily steer gain	1.92 lb.	1.94 lb.
Total number calves: both sexes	86	69
Av. calf weight: both sexes	400 lb.	413 lb.
Av. calf gain: both sexes	244 lb.	252 lb.
Av. daily gain: both sexes	1.84 lb.	1.91 lb.

TABLE 2—Weights and gains of cows and calves by years, on control and wild land pasture, at Lake City Experiment Station

	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950
No. days on experimental pasture..	147	141	140	140	113	125	121	119	127	118
No. cows on control pasture.....	8	10	12	18	5	9	6	6	6	6
Av. cow gain, control pasture (lb.)	93	123	81	108	127	73	58	36	75	78
No. cows on wild pasture.....	8	11	8	8	5	6	6	6	5	6
Av. cow gain, wild pasture (lb.) .	39	−11	−33	71	36	−77	64	−7	80	84
Control pasture heifer calves										
No. of calves.....	4	7	5	10	2	5	1	3	3	3
Av. initial age (days).....	...	41	42	40	59	29	49	50	41	59
Av. initial wt. (lb.).....	...	144	148	157	141	131	190	163	167	199
Av. final wt. (lb.).....	361	405	373	411	383	383	420	342	380	422
Av. wt. gain (lb.).....	205	261	225	254	242	252	230	179	213	223
Wild pasture heifer calves										
No. of calves.....	1	5	2	4	1	2	1	3	3	3
Av. initial age (days).....	...	42	39	41	59	38	43	49	42	66
Av. initial wt. (lb.).....	...	143	134	156	193	164	186	169	165	205
Av. final wt. (lb.).....	406	374	394	437	414	402	418	372	426	453
Av. wt. gain (lb.).....	266	231	260	281	221	238	232	203	261	248
Control pasture steer calves										
No. of calves.....	4	3	7	8	3	4	5	3	3	3
Av. initial age (days).....	...	40	45	42	36	22	29	43	38	56
Av. initial wt. (lb.).....	...	154	174	162	158	127	136	177	162	193
Av. final wt. (lb.).....	408	435	421	432	385	381	356	435	406	434
Av. wt. gain (lb.).....	271	281	247	270	227	254	220	258	244	241
Wild pasture steer calves										
No. of calves.....	7	6	6	4	4	4	5	3	2	3
Av. initial age (days).....	...	39	40	26	53	32	30	45	33	59
Av. initial wt. (lb.).....	...	160	166	139	188	150	141	190	138	208
Av. final wt. (lb.).....	400	423	436	430	417	419	378	414	393	454
Av. wt. gain (lb.).....	251	263	270	291	229	269	237	224	255	246

1941. It was decided to remove the cattle whenever the calves failed to gain 1 pound per day as indicated by the monthly weight periods.

No livestock had grazed on the wild pasture for about 5 years, so there was considerable reseeding and grass growth as well as shrub and tree vegetation. This situation was a factor in reducing the number of cattle after the first two grazing seasons. The wild land pasture growth started slowly in the spring, while the control pastures grew faster and would have provided longer grazing periods. Dry periods tended to influence growth on the wild pasture and caused the vegetation to dry up more rapidly in comparison with pasture on heavier land.

Other pasture areas were designated as control pasture, and there was always adequate grazing for the control cattle. During the first 5 years, the control pasture was largely smooth bromegrass with a small amount of alfalfa, as well as some bluegrass and wild white clover. During the last 5 years, a bluegrass pasture was limed and fertilized, resulting in a good wild white clover grass mixture.

A mixture of equal parts of salt and bonemeal was available for all cattle. The cows were wintered in one group, chiefly on hay; while heifer replacements were fed separately. Other pasture areas provided grazing for all cattle before and after the experimental grazing periods. Good registered Hereford bulls were used, and eventually a few registered cows were added from the purebred Michigan State University herd.

Uneven distribution of calves by sexes in the two types of pasture was due to cows calving after going to pasture. In the later years, cows and calves were paired for more direct comparisons. Very young calves and orphans were excluded from consideration, and only mothers of experimental calves were included in the data for cows.

The entire 10-year experiment is summarized in Table 1, and more detailed information for each year is given in Table 2.

Summary and Conclusions

All cows went to pasture in exceptionally good flesh and were of comparable age, weight, and breeding in each test group. Cows on the control pasture gained weight each year while nursing their calves. The gain, averaging 89 pounds per cow, varied from 36 to 127 pounds.

Cows on wild land pasture lost weight 4 out of 10 years, but they gained an average of 29 pounds per year during the 4 to 5 months of experimental grazing. They outgained the control cows by 5 and 6 pounds, respectively, the last 2 years, even though the control cows were on good, fertilized pasture.

There was no apparent correlation between cow gains and calf gains. In 1943 and 1946, when cows on wild land lost the most weight, their steer calves gained more than the control calves; in 1943, their heifer calves outgained the control heifer calves.

Calves on the two kinds of pasture averaged similar gains over 10 years (Table 1). Wild land heifer calves gained an average of 245 pounds, while control heifer calves gained 236 pounds during the 10-year period. The steer calves gained 255 and 252 pounds, respectively. An average of both sexes together shows a gain of 252 pounds per head for calves on wild pasture and 244 pounds on control pasture.

A study of the data for each year in Table 2 shows not only that the amount of difference in weight was variable, but that neither kind of pasture produced consistently heavier calves. Three times the control pasture heifer calves gained more, and six times wild pasture

heifers gained more, with 1 year producing practically equal gains. The same situation prevailed with steer calves but in different years, with one exception, 1942.

Final calf weights were good for calves of their age. To obtain ages for each year, add "days of pasture" in Table 2 to "average initial age." The average age for all calves was about 173 days at the close of experimental grazing.

The final carrying capacity of the 60-acre wild land pasture was six cows, six calves and one bull, or about 8.5 acres per cow. It was shown that, with sufficient acreage, quite satisfactory calves can be produced on such pasture. No measure was made of acreage grazed by cattle in the control group.

CHEMICAL AND CULTURAL METHODS OF CONTROLLING WEEDS IN PICKLING CUCUMBERS[1]

By S. K. RIES

DEPARTMENT OF HORTICULTURE

WEEDS ARE A BIG PROBLEM to cucumber growers. Cucumbers do not compete well with weeds and must be free of them for best growth and effective harvest.

Most prevalent in the cucumber-growing areas of Michigan are annual broadleafed weeds, annual grasses, and quackgrass (*Agropyron repens*). In controlling these weeds mechanically, many growers injure the crop because they do not consider the extensive root system developed by the cucumber plant during early growth.

In this report, weed control studies conducted in 1956 and 1957 have been divided into three parts: (a) chemical control of annual grasses and broadleafed weeds; (b) chemical control of quackgrass; and (c) a comparison of the effects of various weed control methods on the growth of cucumbers.

CHEMICAL CONTROL OF ANNUAL GRASSES AND BROADLEAFED WEEDS

Members of the cucurbitaceae family were found to be very susceptible to all of the chemicals first employed as selective herbicides; e.g., 2,4-D, stoddard solvent, and the dinitro compounds.

The first promising herbicide for use on the cucurbitaceae family was NPA (N-1 napthyl phthalamic acid), reported for use on muskmelons by Warren (1950). Other workers (Meador and Hemphill, 1951; Sweet and Ries, 1952; Sweet and Ries, 1953; and Warren, 1950) demonstrated successful weed control in cucumbers with this material, and to date this is the only chemical recommended for control of annual weeds in cucumbers.

[1]These investigations were supported in part by the National Pickle Packers' Association.

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To be effective, this material must be applied to soil which is moist at time of application or which is moistened immediately thereafter. NPA is effective only on germinating weed seeds, and the soil must be completely free of germinated weeds at time of application.

Methods

Five experiments during 1956 and 1957 compared new herbicides with two forms of NPA; four trials were applied pre-emergence, and one trial was applied post-emergence. The variety Wisconsin SMR-12 was used in each test. Four of the experiments were conducted on a Wauseon sandy loam at East Lansing; one was on a Miami silt loam at Sodus in southwestern Michigan.

The cucumbers were seeded in rows 5 feet apart with a Planet Junior seeder. After emergence, they were thinned to approximately a 12-inch spacing in the row. The chemicals for all experiments were applied with a small plot sprayer (Ries and Terry, 1952) at a rate of 36 gallons of water per acre and at a pressure of 25 p.s.i. (pounds per square inch).

The following materials were tested: N-1 napthyl phthalamic acid, (NPA or Alanap-1); sodium salt of N-1 napthyl phthalamic acid (NPA or Alanap-3); 2 chloroallyl diethyl dithiocarbamate (CDEC or Vegadex); Alpha chloro-N-N-diallylacetamid (CDAA or Randox); Ethyl N, N-di-n-propylthiolcarbamate (EPTC); 1-n-butyl-3-(3, 4-dichlorophenyl)-1-methylurea (neburon); 2 methyl, 4 chlorophenoxy butyric acid; and four esters of trichloroacetic acid.

Results

During the 2-year period, the only chemicals tested which controlled weeds without causing injury to the cucumbers were Alanap-1, Alanap-3, and Vegadex, at 4 pounds per acre each. Table 1 gives the performance of these materials in each test.

These materials did not give commercially acceptable weed control in the second test at East Lansing in 1957. This probably was due to a 3-inch rain on the day after the chemicals were applied. In the single post-emergence test, these treatments did not give commercial weed control, probably because of dry soil conditions.

In the other three pre-emergence tests, Alanap-1, Alanap-3, and CDEC (at 4 pounds per acre each) gave commercial weed control

TABLE 1—Summary of the performance of the best herbicides tested on pickling cucumbers

Conditions	1956—East Lansing		1957—East Lansing		1957—Sodus
	Pre-emergence	Post-emergence	Pre-emergence	Pre-emergence	Pre-emergence
Planting date	June 11	June 11	June 3	July 3	June 23
Chemicals applied	June 13	July 9	June 4	July 10	June 23
Moisture conditions at time of treatment	Soil surface moist	Soil moist at 2 inches	Soil moist at ½ inch	3 inches of rain on July 11	½ inch rain on June 23

RATINGS AND YIELDS

Chemical	Rate (pounds per acre)	Weed control(*a*)	Yield (bu./-acre)	Weed control(*a*)	Yield (bu./-acre)	Weed control(*a*)	Injury(*b*)	Weed control(*a*)	Injury(*b*)	Weed control(*a*)	Injury(*b*)
None	..	1.0	166	1.7	192	1.0	1.0	1.0	1.0	2.6	1.0
NPA (Alanap-1)	4	7.0	168	4.0	178	...	...	3.3	1.0	...	...
NPA (Alanap-3)	4	7.7	172	4.7	171	5.7	1.0	3.3	1.0	6.3	2.3
CDEC (Vegadex)	4	5.7	152	...	...	7.7	1.0	3.3	1.0	6.0	1.0
Least significant difference at 5 percent level	..	2.6	NS(*c*)	NS	NS	1.8	NS	2.2	NS	3.2	NS
Coefficient of variation (percent)	..	33	14	44	12	24	21	25	14	37	52

(*a*) Weed control rating scale: 1.0 = no control; 6.0 = commercially acceptable control; 9.0 = eradication of weeds.
(*b*) Injury rating scale: 1.0 = no injury; 9.0 = eradication of crop.
(*c*) Not significant.

without injury to the plants. Fig. 1 illustrates the excellent weed control that may be obtained with Alanap-3 when the soil is moist at time of application and there are no weeds above ground.

Fig. 1. Weed control obtained with Alanap-3, applied in a band at a rate of 4 pounds per acre immediately after planting.

Discussion

CDEC was the only material tested that was as effective as NPA in these trials. There was no difference in weed control or injury between the two forms of NPA (Alanap-1 and Alanap-3). However, since Alanap-3 is available as a water-soluble material, it would be easier for growers to use it rather than Alanap-1, a wettable powder.

CDEC, after a heavy rain, was no more effective than either form of NPA. Not enough information was obtained to determine if this chemical may provide more effective weed control than NPA under dry soil conditions (the most important limiting factor in the use of Alanap).

CONTROL OF QUACKGRASS

Quackgrass (*Agropyron repens*) is the most troublesome perennial weed found in Michigan cucumber fields. Many workers have demonstrated that dalapon (2, 2, dichloroproprionic acid) is an effective

herbicide for quackgrass control (North Central Weed Control Conference, 1955; Southwick, 1955). In addition, the cost of the material and the effective rates are low enough to warrant its use on land to be planted to cucumbers. Grigsby et al. (1955) demonstrated that this material could be used close to the time of planting of various crops, including pickling cucumbers.

However, further information is needed, on the time, rate, or combination of rate and time that is best for grass control prior to the growing of cucumbers. This study sought to determine: (a) the effects of early versus late and split applications of dalapon on quackgrass control and crop yield; and (b) the influence of fertilizer applications prior to treatment on the effectiveness of herbicides (Zick and Buchholtz, 1955).

Materials and Methods

The quackgrass population in the field chosen for this study was uniform and low in vigor. The infestation was so complete that no annual weeds were present during the growing season. The soil was a Hillsdale sandy loam.

The plot design consisted of nine blocks 64 feet long and 25 feet wide in a 3 by 3 latin square. The three treatments applied April 5, 1956, were (1) no fertilizer; (2) 121 pounds of ammonium nitrate (33 percent N) per acre; and (3) 333 pounds of 12-12-12 per acre. The quackgrass had 2 inches of new growth at this time. Each of these blocks was split into eight plots (8 feet by 25 feet), and the herbicide treatments were randomized in each block.

The herbicide applications, expressed as pounds per acre of 2, 2 dichloroproprionic acid (sodium salt), were as follows: (1) none, (2) 4.2 pounds early application, (3) 4.2 pounds late, (4) 4.2 pounds early plus 4.2 pounds late, (5) 8.5 pounds early, (6) 8.5 pounds late, (7) 8.5 pounds early plus 8.5 pounds late, and (8) 17.0 pounds early. The chemicals were applied with a small plot sprayer, with carbon dioxide as a source of pressure and quart bottles as herbicide containers.

The early treatments were applied May 10 when the grass was 4 to 6 inches high. This area was plowed on May 21. The late applications were applied June 19 when the quackgrass was 6 to 8 inches high. The quackgrass was disced under on June 21 and the entire experimental area was fertilized with 400 pounds of 5-20-20 per acre, which was broadcast before preparation for planting. Four days later, Ohio MR-17 pickling cucumbers were planted.

Enough moisture was available for good growth of grass and crops during the months of May, June and July. Rainfall during these three months was 6.3, 2.8, and 2.5 inches, respectively.

Quackgrass control ratings for the early applications were made on June 18; they were made for all treatments on August 1. The cucumbers were harvested about every 3 days.

Results

The first quackgrass ratings (Table 2), made before the second series of herbicide treatments were applied, indicated that commercial weed control was obtained with both the 8.5 and 17 pound per acre application of dalapon. There was no indication at this time that the fertilizer application influenced weed control. Fig. 2 shows the con-

TABLE 2—Quackgrass control ratings made June 18 on early (May 10) applications of dalapon

Treatments (pounds per acre active ingredient)	Rating(*a*) (av. of nine plots)
Check	1.0
4.2 pounds early	5.7
8.5 pounds early	7.0
17 pounds early	8.2
L.S.D.(*b*) at 5 percent	.6
L.S.D. at 1 percent	.8

(*a*) Rating scale: 1.0 = no control; 6.0 = commercially acceptable control; 9.0 = complete eradication.
(*b*) Least significant difference.

Fig. 2. Left foreground: quackgrass control with 17 pounds per acre of dalapon. Right foreground: plowed only. Background: undisturbed quackgrass.

TABLE 3—Yield records and quackgrass control ratings made August 1 on early (May 10) and late (June 18) applications of dalapon

Treatment	Cucumber yield bu./acre av. of nine plots	Rating(*a*)
None	270	1.3
4.2 early	243	2.8
4.2 late	232	4.6
4.2 early+4.2 late	274	4.8
8.5 early	260	4.2
8.5 late	227	6.6
8.5 early+8.5 late	213	6.9
17 early	290	6.2
L.S.D.(*b*) at 5 percent	NS	1.1
L.S.D. at 1 percent	NS	1.5

(*a*) Rating scale: 1.0=no control; 6.0=commercially acceptable control; 9.0=eradication.
(*b*) Least significant difference.

trol obtained with the 17 pound per acre application of dalapon; it also shows the heavy stand of quackgrass in the unplowed area.

Quackgrass control ratings made on August 1 (Table 3) show that commercially acceptable weed control (less than one shoot per square foot) was obtained only by application of 17 pounds early, 8.5 pounds late, or the combination of 8.5 pounds early and 8.5 pounds late. The yield records presented in Table 3 indicate that the cucumbers were not injured by any treatment.

The quackgrass control ratings presented in Table 4 indicate that the best control from all dalapon applications was obtained when the

TABLE 4—Effect of fertilizer applications before chemical treatments on quackgrass control

Fertilizer application (rate per acre)	Rating(*a*) (av. of 21 plots)
None	4.1
333 lb. 12-12-12	5.3
121 lb. 33-0-0	6.0
L.S.D.(*b*) at 5 percent	.6
L.S.D. at 1 percent	.9

(*a*) Rating scale: 1.0=no control; 6.0=commercially acceptable control; 9.0=eradication.
(*b*) Least significant difference.

grass had been fertilized earlier. The grass control was directly related to all treatments within the different fertilizer applications.

Discussion

Previous research (Grigsby et al., 1955; North Central Weed Control Conference, 1955) has indicated that dalapon occasionally causes injury to vegetables planted as soon after application of dalapon as in this test. The early part of this season, however, was characterized by heavy rainfall and warm temperature which favored dalapon breakdown; no injury resulted.

Test results appear to justify the following conclusions:

1) Commercially acceptable control of pure stands of quackgrass was obtained with: (a) 17 pounds per acre of dalapon applied in early May; (b) 8.5 pounds applied in late June; and (c) 8.5 pounds applied in early May and 8.5 pounds again in late June.

2) The application of 40 pounds of N per acre (or its equivalent as 12-12-12) to quackgrass low in vigor increased the effectiveness of quackgrass control by dalapon. The application of 12-12-12 did not increase the effectiveness of the dalapon compared to the ammonium nitrate.

3) Cucumbers were not injured by any treatment.

4) Split applications of dalapon, 4.2 pounds early plus 4.2 pounds late, and 8.5 pounds early plus 8.5 pounds late, were no better than a single application of 8.5 pounds late.

A COMPARISON OF VARIOUS METHODS OF CULTIVATION

The root system of seedling cucumber plants develops very rapidly. Fig. 3 shows that the shoot growth of a 1-week old cucumber plant is not proportional to its root development. Although the first primary leaf is just showing, the primary root of one plant is 6 inches long; the lateral roots of the other are 3 inches long.

Weaver and Bruner (1927) reported that a 4-week old cucumber plant had both primary roots and lateral roots over 2 feet long. At this time, the plants averaged 5 inches in height, with a total spread of 8 inches. These workers also found that the major portion of the root development was in the top 8 inches of soil.

Thompson et al. (1931) first indicated the possible harmful effect of improper cultivation. Several years of testing with carrots, cabbage,

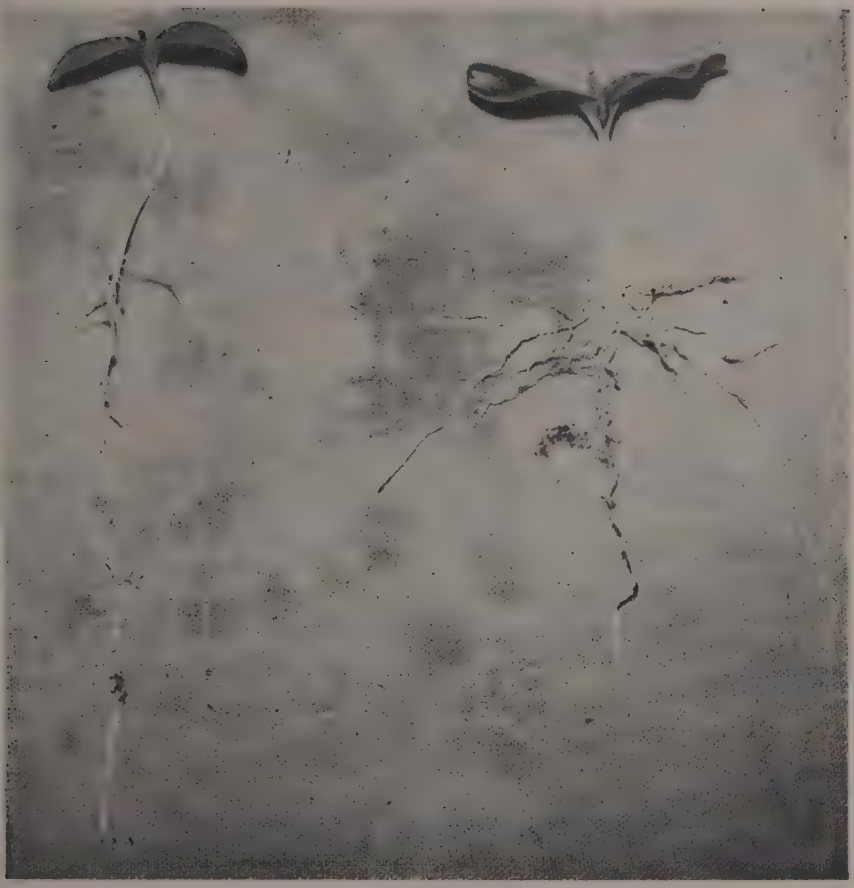

Fig. 3. Root system of pickling cucumber plants 7 days old; variety, Wisconsin SMR-12.

onions, oats, tomatoes and potatoes indicated that the main advantage of cultivation was weed control. Thompson also concluded that "deep cultivation is seldom, if ever, justified and is certain to be injurious after the roots have developed in the zone reached by the cultivator."

In spite of the information available on the purposes and methods of cultivation, many growers still cultivate too deeply and more often than necessary.

The following study compared weed control by means of shallow and deep cultivation, herbicides, black polyethylene mulch and hand-

weeding. In the latter two methods, the soil surfaces were not disturbed by cultivation.

Methods

The pickling cucumber, variety Wisconsin SMR-12, was seeded in rows 5 feet apart on two soil types: a Wauseon fine sandy loam high in organic matter, and a Spinks loamy sand low in organic matter. Five treatments were made in randomized blocks with four replications on both soils: (1) weeds cut at surface with a hoe; (2) 4 pounds of Alanap-3 per acre, applied June 4; (3) black polyethylene (1.5 mils) mulch 3 feet wide, applied June 12 when cucumbers had one true leaf; (4) four shallow cultivations (1 to 2 inches deep) with sweeps when needed for weed control; and (5) four deep cultivations (4 to 6 inches deep), with shovels, when needed.

An identical stand of one plant per foot was maintained on all plots. Weeds not killed by cultivation or weed control chemicals were pulled by hand in two weedings. Hand-weeding was necessary on chemically treated heavier soils due to poor weed control on this soil. It was not necessary to disturb the plots having the black polyethylene mulch.

Results

The cucumbers responded similarly to all treatments on both soil types. Table 5 gives the average yield per treatment for both soil types.

TABLE 5—Average yield of marketable pickling cucumbers from various cultural treatments on two soils

Treatment	Yield (bu./acre) nine harvests 7/24 to 8/23
Weeds hand-pulled	391
Chemicals only	380
Black plastic	384
Shallow cultivation	375
Deep cultivation	318**

** F value significant at 1 percent level for this treatment compared with others.

The yield from plots which received deep cultivations 4 to 6 inches deep, 6 to 12 inches from the row, was less than that in all other plots on both soil types. The average reduction was 64 bushels per acre, or a loss in yield of 17 percent.

The use of black plastic did not increase the total yield on either soil, although it increased the early yield on the lighter soil type.

Discussion

These results indicate that shallow cultivation and the use of herbicides are the most practical methods of weed control. The decrease in yield of 17 percent undoubtedly was due to "root pruning." Broken roots were found in the plots cultivated deeply. This is a condition often seen in commercial fields. If weeds are controlled by chemicals, it is not necessary to cultivate unless a hard crust is formed; this did not occur in these tests.

Shallow cultivation probably is best done with sweeps 6 inches or more in width. Since it is difficult not to cultivate very deeply when using shovels, it is best to avoid their use in the cultivation of cucumbers.

SUMMARY

Studies on the use of chemicals and cultivation for control of weeds in pickling cucumbers indicated:

1) Only one new herbicide, CDEC (Vegadex), at a rate of 4 pounds per acre, was as effective in pre-emergence weed control as either form of NPA (Alanap-1 or Alanap-3).
2) Ten pounds of dalapon per acre can be used effectively to control quackgrass before the planting of pickling cucumbers. This material should be applied to quackgrass at least 4 inches tall 5 weeks before planting cucumbers. If the quackgrass is not growing vigorously before application, 30 to 50 pounds of nitrogen per acre should be applied to stimulate growth.
3) The cucumber plant up to 4 weeks old has a much larger root system than the top growth would indicate; this root system is concentrated in the top 8 inches of soil. Deep cultivation (4 to 6 inches) caused a decrease in yield. Sweeps are probably better than shovels for cultivating cucumbers because they effectively cut off weeds without disturbing the roots.

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A MECHANIZED LAYING HOUSE FOR MORE DENSELY POPULATED FLOCKS

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DURING THE SUMMER of 1956, a "new" type of poultry house was constructed in Lapeer County on the farm of Roy Spencer. This provided an opportunity to adapt clear-span roof trusses and insulated walls to a poletype poultry house.

Automation and mechanization in this house included three exhaust fans, two mechanical cleaners, two mechanical feeders, and many automatic waterers.

The environmental conditions of this house were studied during a test period beginning January 1, 1957 and ending May 31, 1957. Recording hygrothermographs were used to obtain temperature and relative humidity data inside and outside of the house. Other regular measurements included litter moisture content, quantity of droppings, and water removed by the pit cleaners.

Egg production and livability of the birds under test were recorded throughout the test.

The first season of operation was termed successful by the poultryman-owner-operator, as well as by the researchers. Inside temperature never dropped below the 42° F. level at which the thermostat was set, although outside temperature dropped to 5° F. below zero. No supplemental heat was used at any time in this house. The litter remained dry and workable, and detectable odors were not present.

NEED FOR STUDY

A dry and warm poultry house must be properly insulated and correctly ventilated. Constructing such a house is costly. Equipping it with mechanically-operated ventilation fans, dropping pit cleaners, mechanical feeders, and automatic waterers adds more to the total cost. However, with these facilities and proper management, the

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owner-operator was able to double the number of laying hens for a given floor area. This reduced the cost per bird housed and increased the efficiency of the operation enough to make it practical and economical.

POINTS INVESTIGATED

1. Adaptation of clear-span roof trusses to poultry houses.
2. Installation and effectiveness of applying insulation to a poletype structure.
3. Effectiveness of thermostatically-controlled fans.
4. Value of dropping pit cleaners in removal of moisture.
5. Performance of laying birds housed at a density of less than 3 square feet of floorspace per bird.

DESCRIPTION OF HOUSE

A 36- by 108-foot poletype building with a clear-span wood truss roof was constructed. The outside of the house was completely covered with corrugated sheet metal (Fig. 1).

Fig. 1. The 36-foot by 108-foot poultry house was constructed as an addition to a 36-foot by 36-foot concrete block building which now serves as a feed and utility building. The power units for the two dropping pit cleaners and the cross-elevator are located at one end of the building. The building is roofed and sided with sheet metal.

The house was an addition to an existing block building which serves as a feed and utility room. A mechanical cross-conveyor and elevator at the west end of the house receives the droppings from the two 8-foot wide cleaners and moves them into a spreader.

The two dropping pit cleaners with one level of roosts and feeders were installed in this house, instead of a multiple roost deck system with two levels of feeders and waterers. Fig. 2 shows the framing of one dropping pit in the foreground; the second one is in the background. The frame over each pit is 12 inches high with 2-inch by 2-inch roost boards 14 inches apart covered with 1-inch by 2-inch welded wire mesh. A mechanical feeder loop and a number of waterers were installed over each pit.

Fig. 2. The 36-foot wide building is provided with two 8-foot wide dropping pits with mechanical cleaners. Roosts, mechanical feeders, and waterers are placed over the two pits. The time switch has just started fresh feed down one side of the feeders where the birds are eating.

The floor is a 4-inch flat concrete slab. The dropping pits were constructed on top of the slab without any deflations or cutouts.

The wall construction of this poletype house is shown in Fig. 3. Pressure-treated poles spaced 12 feet on center were framed inside and out with horizontally-applied wall girts. These girts, spaced 2 feet apart, provided for the horizontal application of a 24-inch wide and 2-inch thick blanket insulation. Although all blanket insulation is covered with a vapor barrier, a second barrier of aluminum foil was placed over the wall girts.

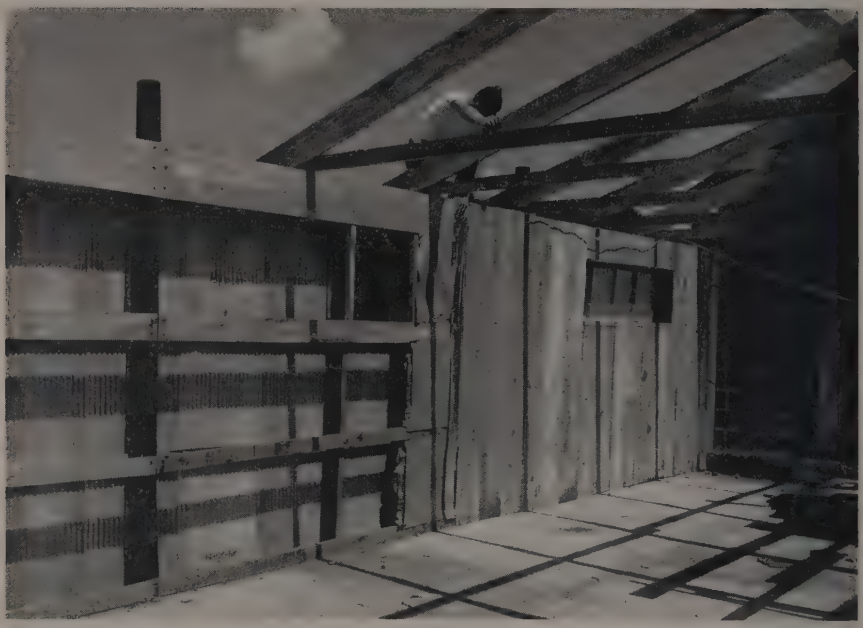

Fig. 3. The poletype poultry house was sheathed inside and out and insulated for maximum heat preservation. Sheet metal was used outside; boards were used inside. The 2-inch by 24-inch blanket insulation was placed horizontally between wall girts. An aluminum foil vapor barrier was placed between the blanket insulation and interior sheathing boards.

The horizontal wall girts also provided for the vertical application of interior and exterior sheathing. The interior sheathing consisted of 1-inch boards.

Windows 2 feet high and 6 feet long were installed between the top two wall girts. The ceiling was sheathed and insulated similar to the sidewalls.

Wood trusses for the roof were constructed on the floor (Fig. 4). The truss members were cut to length and drilled for bolts and split rings by mass production techniques.

Fig. 5 shows the placing of the trusses on the sidewalls with a farm tractor and front end loader. The clear-span trusses were spaced 4 feet on center. The use of split-ring connectors and bolts provides strong joints that efficiently utilize the potential strength of the wood members.

Fig. 4. The trusses are bolted together in a horizontal position on the concrete floor. The rafters (upper cords) of the trusses are 2-inch by 8-inch members; all other parts are 2-inch by 4-inch pieces. The strong joints of these trusses make them capable of spanning 36 feet without support and with minimum board feet of lumber.

By eliminating the interior poles and additional roof purlins required in conventional pole construction, this clear-span roof was built without additional cost. It provides a flexible building without interior obstructions. Complete use can be made of all space below the trusses.

The roof deck was constructed of 2-inch by 4-inch girts, spaced 2 feet apart on the 4-foot spaced trusses. Twenty-eight gage 2½-inch corrugated sheet metal was applied over the roof girts.

VENTILATION

Three exhaust fans, each with a rated capacity of 3,300 c.f.m. (cubic feet per minute), were installed in the north wall. Air inlets were all on the opposite side of the building; thus, all the air was moved across the width of the building.

The inlets from the attic consisted of 6-inch by 72-inch openings above each of the nine windows on the south side of the house. Fresh

Fig. 5. The 36-foot trusses were easily lifted into position on the building with a light farm tractor and loader. The trusses were spaced 4 feet on center. The roof deck was constructed with 2-inch by 4-inch girts spaced 2 feet on center across the trusses. The girts can be placed in a flatwise position; it is only with wider spacing of trusses or rafters that they need be placed on edge for greater strength.

air enters the attic through 48-inch by 48-inch louvers in the gable ends of the building.

Fig. 6 is a shematic diagram of the ventilation air circulation. The cool, fresh air flows downward from the ceiling and keeps the windows

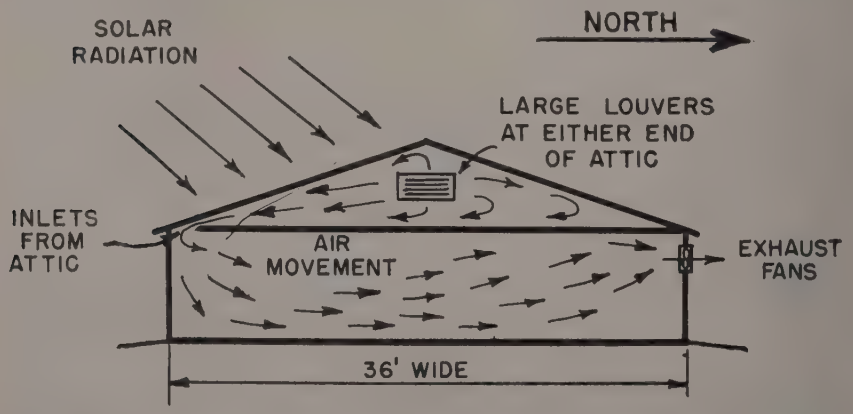

Fig. 6. Schematic diagram of exhaust ventilation system with inlets from the attic.

on that sidewall clear of condensation. Air is drawn on across the room by the exhaust fans. All fans are controlled by one thermostat.

COST OF HOUSE

Roy Spencer built this house with a negligible amount of outside labor. The cost of construction, including concrete floor and exhaust fans, was 1 dollar per square foot of floorspace. Most of the lumber used was native-sawn, although pressure-treated poles were used.

All equipment, including pit cleaners, end conveyor, feeders, waterers, and nest, cost about 1 dollar per square foot of floor area. Thus, house and equipment cost 2 dollars per square foot of floor area.

Twenty-two hundred pullets were housed in this building during the winter of 1956-57 at the rate of one bird per 1.8 square feet of floorspace. The out-of-pocket cost for this operation was about $3.50 per pullet housed.

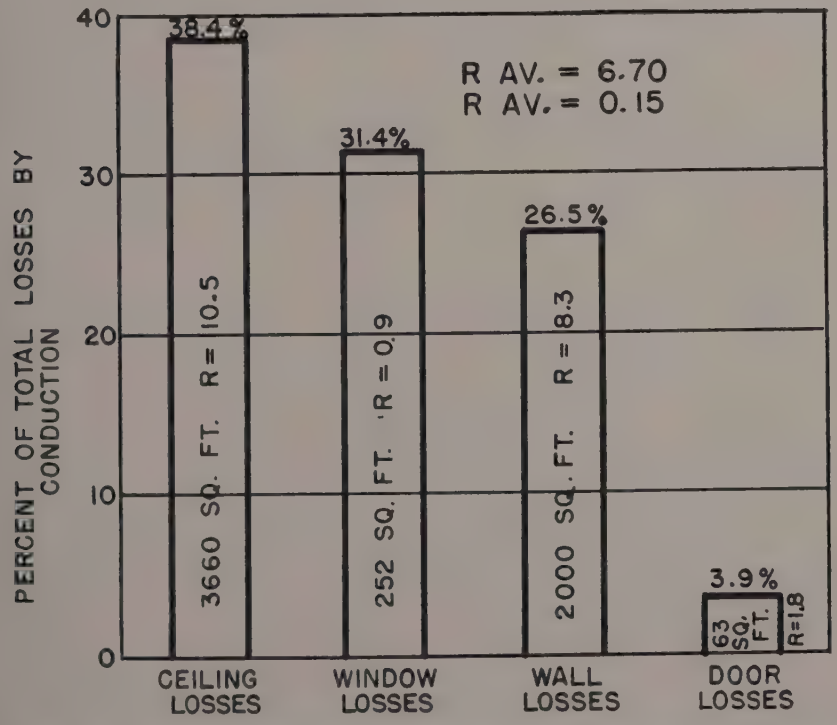

Fig. 7. Calculated distribution of conduction losses from the 36-foot by 108-foot poultry house.

OBSERVATION AND RESULTS

The functioning of the house was completely analyzed. Heat and moisture balances were calculated, and ventilation effectiveness was measured.

HEAT LOSSES

Calculated conduction heat losses through the walls, ceilings, windows, and doors are shown in Fig. 7. These estimates are based on 2-inch blanket insulation material in both sidewalls and ceiling.

Slightly more than one-third of the loss is through the ceiling. Thus, it is important to insulate the ceiling as well as the sidewalls.

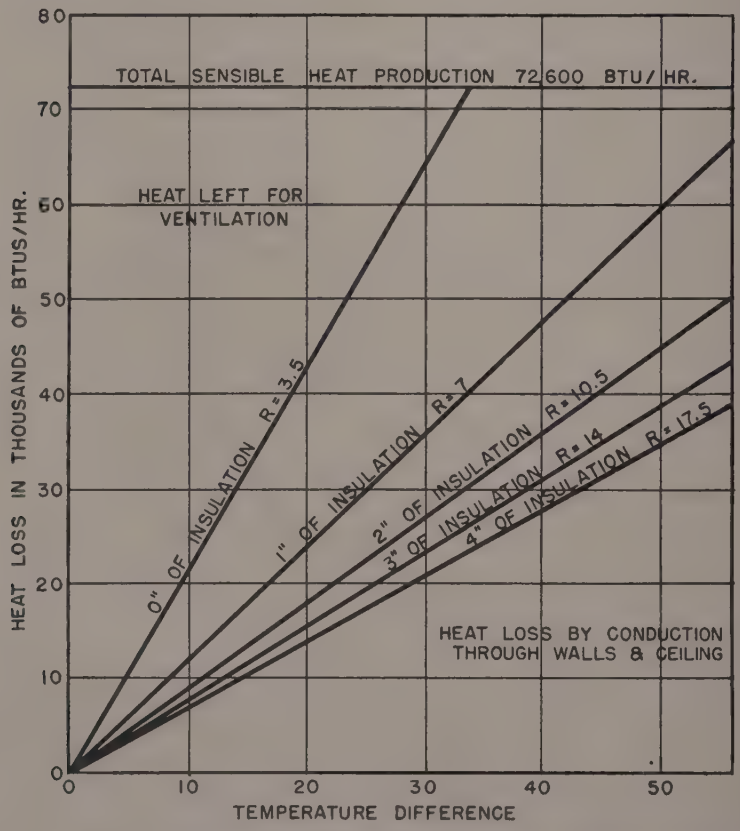

Fig. 8. Conduction losses from the 36-foot by 108-foot poultry house.

The windows account for about another third of the conduction heat loss, even though their comparative area is quite small (the window area represented between 6 and 7 percent of the floor area in this building).

Insulation should retain a maximum amount of the available body heat in a poultry house for ventilation purposes. The effect of various amounts of insulation in the test house was analyzed. Fig. 8 shows that with no insulation between a double-sheathed wall or in the ceiling, all heat is lost by conduction with a temperature difference of 30° F. or more between inside and outside temperature.

This theoretical construction surpasses many poultry houses of the past which were often built with frame walls and sheathing on the exterior side of the framing. These single-walled structures house

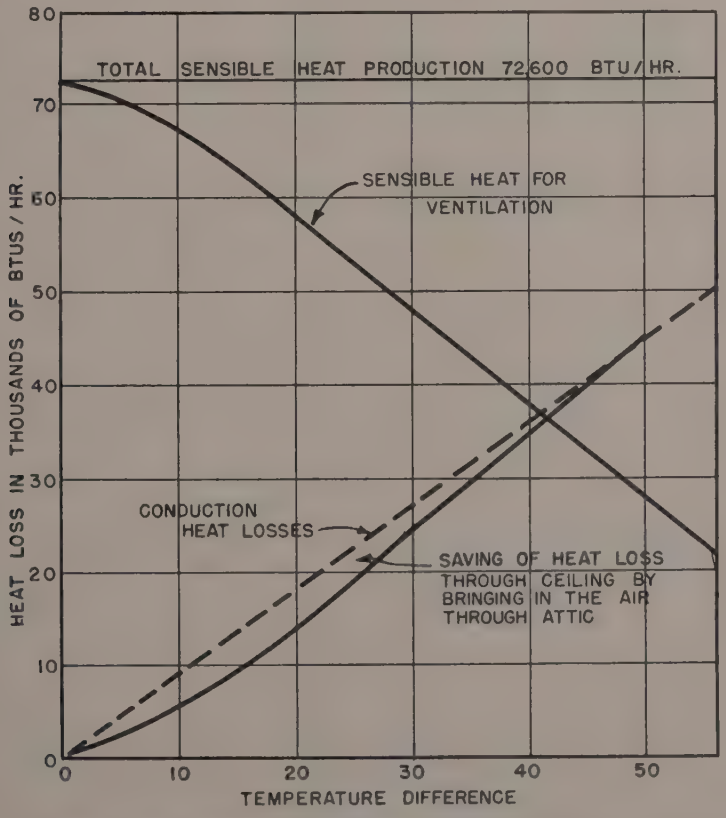

Fig. 9. Heat losses and ventilation from the 36-foot by 108-foot poultry house.

only half as many laying hens (3 to 4 square feet per bird), making the situation worse because only half as much body heat is available.

Addition of 1 inch of insulation reduces heat losses by 45 percent (and 2 inches by 60 percent), compared to no insulation. With the 2-inch insulation of this house, nearly one-third of the total heat is available for ventilation with a 55° F. temperature difference. The third and fourth inch of insulation add proportionally less to the overall heat-preserving characteristic.

Ventilation air can only be provided for removal of moisture and odors to the extent that it uses excess body heat in the poultry house. If more air circulation is provided, a cool house results. Thermostatically-controlled fans tend to prevent this overcooling. If, however,

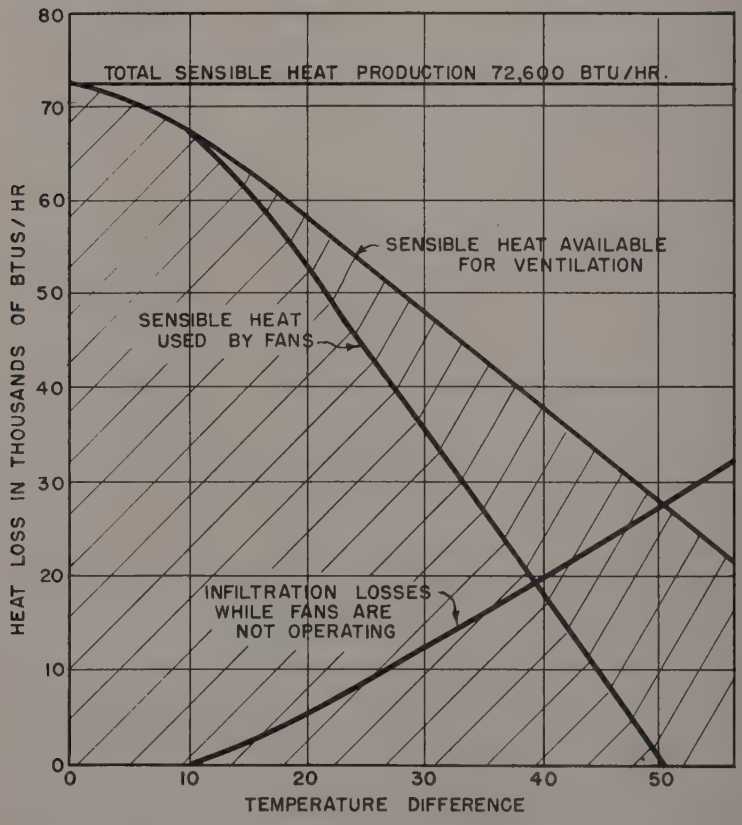

Fig. 10. Heat utilization by fans, and exfiltration in the 36-foot by 108-foot poultry house.

heat is not sufficiently preserved by insulation, for adequate ventilation, a wet, unhealthful building can result.

Along with the conduction losses shown in Fig. 8, Fig. 9 shows the amount of heat which can be used for ventilation purposes (ventilation here is interpreted to mean air exchange by both natural exfiltration and mechanical fans). Fig. 9 also shows that an additional conduction heat is gained by bringing the ventilation air into the house through the attic. While the fans are in operation, the incoming air picks up any heat lost through the ceiling by conduction.

Fig. 10 shows a division of the heat available for ventilation into natural exfiltration and fan operation. Infiltration will vary with wind direction and intensity (Fig. 10 illustrates a normal division for this particular poultry house).

Heat loss measurements indicated that an equivalent of one air change per hour takes place while the fans are out of operation. With a temperature difference of about 50° F., the fans would not operate at all in this house. This was verified by actual operation at this temperature spread between inside and outside.

The length of time the fans operated at various temperatures was measured and calculated, based on heat available for ventilation. At 30° F., outside temperature (which is a 12° temperature difference based on the constant 42° F. inside temperature), these fans ran constantly. The percentage of operating time drops off rapidly, however, as the outdoor temperature falls below 30° F.

Fig. 11 shows this reduction of fan operation time in both percentage and air exchange in thousands of cubic feet per minute. For the first 10° F. drop in outside temperature below 30° F., fan operation decreases to 50 percent of the time. While the fans are in operation, all exfiltration air is accounted for by the fans as they keep the interior of the building under a slight vacuum and air moves in instead of out of the cracks. As the proportion of fan operating time decreases with falling outside temperature, the air exchange by infiltration increases to the one air change per hour level at the 50° F. temperature differential when the fans do not run.

MOISTURE REMOVAL

Moisture removal is one of the most important functions of the ventilation system. Laying hens produce about two-thirds of a pound of moisture per day. Seldom does any type of ventilation system remove this much moisture. The result is a wet or a cold house, or both.

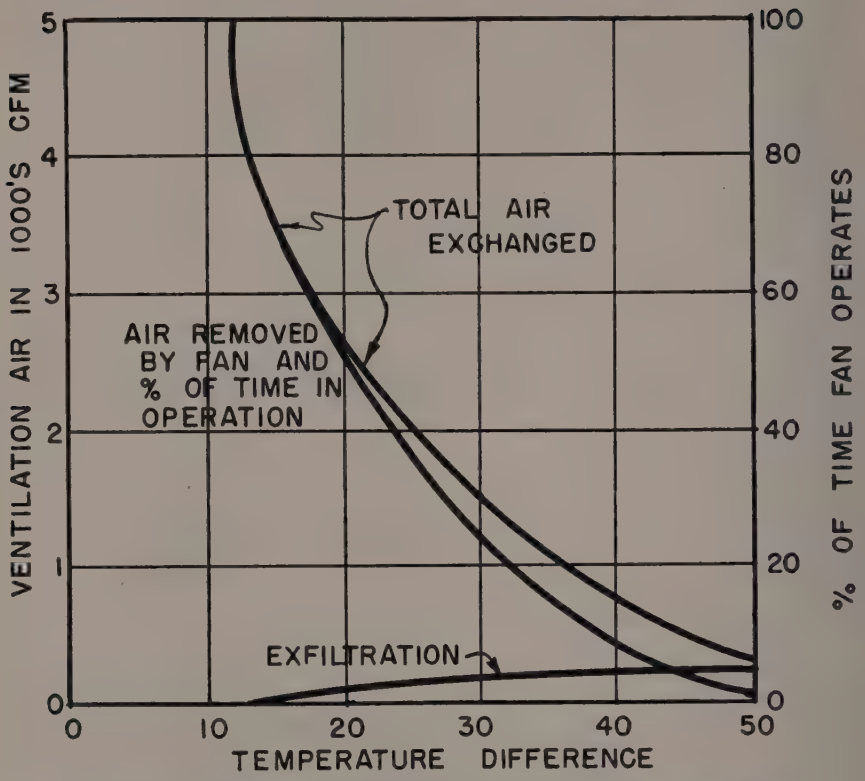

Fig. 11. Ventilation air removed by fan operation, and exfiltration in the 36-foot by 108-foot poultry house.

Mechanical dropping pit cleaners removed droppings three times a week. The amount of moisture removed by the mechanical cleaners was measured. Fig. 12 illustrates graphically the proportion of total moisture removed by the cleaners and the remaining proportion removed by ventilation at various temperature differences.

The total calculated moisture produced by 2,200 laying hens amounted to 60.5 pounds per hour. This is shown by a horizontal line at the top of the graph. Another horizontal line illustrates that an equivalent of 19.6 pounds of water per hour are removed by the dropping pit cleaners (55 gallons per day).

The curved line on the graph shows the amount of moisture removed by ventilation, plus that removed by the pit cleaners. It is significant that there is about a 20° F. temperature difference where a balance in moisture produced and removed occurs. Above this

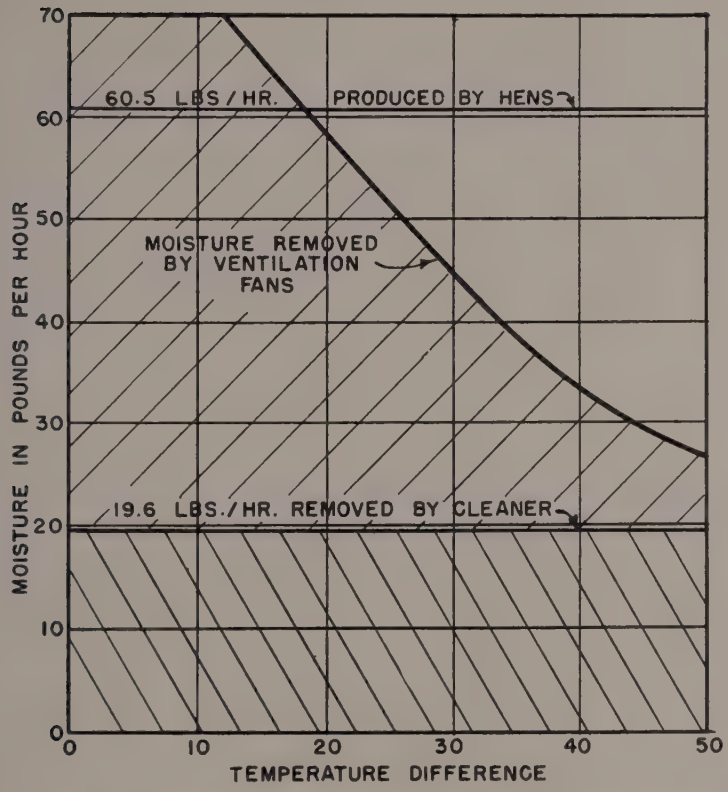

Fig. 12. Moisture removal by ventilation, and droppings removal.

temperature, more moisture is removed than produced; below it, less. This means then that when the outside temperature drops more than 20° F. below inside temperature, moisture accumulates in the building. However, the periods of accumulation did not prove to be long or frequent enough to cause undesirable humid conditions or wet litter. The litter moisture content averaged 43 percent on a wet basis.

Theoretically, if the cleaners were not used in this house, a moisture balance would barely be obtained at zero temperature difference. When outside temperatures were below 42° F., moisture would accumulate. With the cleaners, this house might also be critical from a moisture standpoint if less insulation had been used (Fig. 8), thereby further restricting the amount of mechanical ventilation. Fewer laying hens in this house would also reduce available body heat, and hence ventilation, until moisture became a problem. Increasing the number

of hens in a house adds more moisture, but all of their excess body heat is available for ventilation, thus improving the balance.

SOLAR HEATING OF VENTILATION AIR

Temperature measurements of incoming air from the attic indicated considerable warming, particularly during the day, compared to outside air. This may be desirable from the standpoint of preventing cold drafts near the inlets and for conserving heat, thus providing a better environment in the house during cold weather. During the summer, the windows are opened and air is not drawn through the hot attic.

Some heat is picked up by this incoming air at all times (by conduction losses through the ceiling, as stated previously). Additional heat is gained on the roof during the daylight hours. Solar radiation is absorbed by the sheet metal roofing, conducted through and reradiated to the air in the attic.

An average of a 5° F. warming of the incoming ventilation air was caused by the sun's rays. On an overcast day, outside air temperature must rise to 35° F. before the fans would run continuously. On sunny days, the fans ran continuously at all temperatures above 30° F.

CONCLUSION

1. The clear-span, poletype, insulated poultry house proved to be functional and low in cost.
2. With the equipment provided in this laying house, and with proper management, laying hens were successfully housed at one bird per 1.8 square feet of floor area.
3. The dropping pit cleaners removed about one-third of the total moisture produced by the laying hens. This reduced the moisture removal requirements of the ventilation fans and also eliminated any detectable ammonia.
4. Two-inch blanket insulation in the walls and ceiling of this building conserved enough heat for proper ventilation and drying when 2,200 hens were housed.
5. The three 3,300-c.f.m. fans proved adequate; 4½ c.f.m. rated capacity was provided per bird housed.
6. The exhaust ventilation system with the inlet air being drawn through the attic proved highly successful during the first year of operation. Up to 5° F. warming of the air was caused by sunshine

on the roof under winter conditions; additional conduction heat was picked up from losses through the ceiling.

7. With the roosts, feeders, and waterers all concentrated over the dropping pits, a majority of the droppings was readily removed by the cleaner without any hand labor.
8. Satisfactory production of 75 percent or higher was maintained in this house.

INVESTIGATIONS WITH PLASTIC COVERS FOR BLUEBERRY PROPAGATING FRAMES

By STANLEY JOHNSTON
DEPARTMENT OF HORTICULTURE

EXPERIMENTS WERE CONDUCTED at the South Haven Experiment Station in the growing seasons of 1955-57, inclusive, with plastic covers for blueberry propagating frames. Glass sash has been used to cover propagating frames for many years and has given satisfactory results. However, it has become expensive, and the glass is easily broken.

The experiment was divided into three parts:

1. To determine if any of the plastic covers, used with a burlap shade, would give as good percentages of rooted cuttings as the combination of glass sash and burlap shade ordinarily used.
2. To determine if colored polyethylene could be used successfully without shade.
3. To determine maximum temperatures under the plastic-burlap shade combination compared to glass with a burlap shade.

Standard box propagating frames were used for the tests (Fig. 1), and granulated peat moss was used as the rooting medium in every instance. The cuttings were all of the Jersey variety and carefully selected for uniformity. General care was that which has become standard in handling box propagating frames in Michigan.[1]

Data in Table 1 show the percentages of rooted cuttings obtained in the years 1955-57, inclusive, in frames covered with clear plastic, wired plastic (clear plastic reinforced with wire mesh), and glass. Each frame was equipped with a shade made of 7½ ounce burlap.

The average percentage of rooting under glass for 3 years was 89, under wired plastic 87, and under clear plastic, the average for 2 years was 84.

[1]Detailed directions for blueberry propagation are given in Michigan Agricultural Experiment Station Circular Bulletin 188, Essentials of Blueberry Culture.

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Fig. 1. Standard box propagating frame used in these experiments. Frame in foreground was covered with plastic cover and burlap shade. Frame in background was covered with the standard glass sash and burlap shade combination. The rooting medium used in all frames was granulated peat moss.

TABLE 1—Percentages of rooted blueberry cuttings obtained in frames with different covers; 160 cuttings were planted under each cover

Type of cover	1955	1956	1957
Glass	93	93	81
Wired plastic	91	88	81
Clear plastic	..	93	75

Polyethylene of different colors was used in 1955 to determine if any of these could be used successfully without burlap shade. The results obtained from this test are shown in Table 2.

TABLE 2—Percentages of rooted blueberry cuttings obtained in propagating frames covered with polyethylene of different colors and without shades; 160 cuttings were planted under each cover

Color of polyethylene covers	Percentage of rooted cuttings
Blue	85
Yellow	72
Clear	11
Red	0
Green	0

While the percentages of rooted cuttings obtained with covers of blue and yellow polyethylene without shades were fairly good, the plants were smaller than obtained with standard methods, and considerable foliage injury was present.

The above experiment was repeated in 1956 using burlap shades over the different polyethylene covers (Table 3).

TABLE 3—Percentages of rooted blueberry cuttings obtained in propagating frames covered with polyethylene of different colors and with shades; 160 cuttings planted under each cover

Color of polyethylene covers	Percentage of rooted cuttings
Clear	93
Red	92
Green	90
Blue	80
Yellow	80

Good percentages of rooting were obtained with red and green polyethylene covers, but the rooted cuttings were not as large as those obtained with clear polyethylene or glass.

Occasionally serious damage is done to blueberry cuttings by high temperatures in the propagating frames during extremely hot days in June. At this time cuttings are in full leaf but have not yet rooted. The temperature within the frame can be lowered somewhat by increasing ventilation. This is a hazardous practice, however, as too much ventilation will cause severe wilting and loss of cuttings.

Temperatures were taken each day in June and July, 1957, by means of recording thermometers in frames covered with glass, clear plastic, and wired plastic. All the frames were equipped with the conventional burlap shade. The highest temperatures occurred on June 16 and 17, and comparative temperatures under the different covers on these dates are shown in Table 4.

The temperature under the glass cover exceeded 100° F. three times during June, 1957; under clear plastic 11 times; and under wired plastic five times. The percentage of rooting was 83 under the glass and wired plastic; and 75 under the clear plastic cover. The

TABLE 4—Maximum temperatures in degrees F. in blueberry propagating frames with various covers on June 16 and 17, 1957

Date	Covers		
	Glass	Clear plastic	Wired plastic
June 16	104	111	100
June 17	99	113	108

lower percentage of rooting under the clear plastic cover might have been due to the considerably higher temperatures under this material.

The propagating frames used in these experiments were located about 500 feet from Lake Michigan. Summer temperatures this close to Lake Michigan are lower than inland. It is quite likely therefore, that temperatures under clear plastic covers might be dangerously high in propagating frames located inland on hot June days when cuttings are in the critical stage.

SUMMARY

1. The average percentage of rooting of blueberry cuttings for 3 years under glass was 89; under wired plastic 87; and under clear plastic covers for 2 years, 84.
2. Polyethylene covers of various colors were used without burlap shades with poor results. Better results were obtained when shades were used, but not as good as obtained with the use of glass or clear polyethylene.
3. Maximum temperatures in propagating frames in the critical period in June were considerably higher under clear plastic covers than under glass or wired plastic. Burlap shades were used in all treatments.

CONCLUSION

Plastic covers have the advantages over glass sashes of lower cost, less weight, greater ease of handling, and less chance of breakage. However, these advantages might easily be offset, in the case of clear plastic, by considerably higher temperatures within the propagating frame on hot days in June or early July when the cuttings are in full leaf and are just starting to form roots.

There are many plastic materials on the market recommended as substitutes for glass. Only a few of these could be tried in this experiment. Of those tried, clear plastic reinforced with a fine wire mesh, gave the best results, considering all factors. Sash with this material can be made and maintained at about half the cost involved in using glass sash. This material shows sufficient promise for the blueberry grower to try it on a moderate scale until more is known about it.

PROGRESS REPORT ON CELERY VARIETIES

By SHIGEMI HONMA
DEPARTMENT OF HORTICULTURE

PERFORMANCE OF NEW celery varieties is of considerable interest to Michigan growers. In 1957 a test was conducted on the Michigan State University muck experimental farm near East Lansing. It included many of the varieties grown in the state, newer varieties from commercial seed companies, and promising new strains from this and other experimental stations. This report summarizes the observations and presents data on the performance of these varieties and strains.

Seeds of all varieties were sown in vermiculite on April 10 and transplanted in flats 30 days later. Plants were set in the field on June 11 at a spacing of 6 inches in the row with 32 inches between rows. The varieties were planted in plots of 22 plants each and replicated four times. Twenty plants from each plot were utilized in obtaining the data. Commercial fertilizer consisting of 1,500 pounds of 5-10-30, 20 pounds of manganese, and 50 pounds of borax per acre, was worked into the soil prior to field setting. Three side dressings of 50 pounds of ammonium nitrate were made, starting a few weeks following transplanting and at 2 to 3-week intervals. The plots were sprayed with D.D.T. and Diathane at 7-day intervals up to 30 days prior to harvest when Malathion was substituted as insecticide.

All varieties were harvested on August 27 and 28. This was the approximate maturity date of Utah 52-70. All data obtained were recorded at the time of harvest. The varieties in Table 1 are arranged in order of total yield of trimmed stalks calculated on the basis of a perfect stand. Data on yield in crates per acre of marketable stalks were calculated by dividing the total trimmed weight by 65 pounds. Weight per stalk was determined by dividing the total trimmed weight by the number of stalks.

Petiole numbers were determined by counting the total number of petioles as seen in a cross section of the stalks which were cut approximately 4 inches above the butt. Petiole length was determined

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Fig. 1. Commercially grown Michigan celery. Top picture—MSU 142; bottom picture—Utah 52-70. Note the uniformity and smooth petiole of MSU 142. All varieties packed in standard Howard crates.

by averaging the measurement of the second shortest petiole on the face of a trimmed stalk. Grades as shown were determined by using a half-size Howard crate since a 20-plant sample was used for each replicate. Aster yellows counts were made at the time of harvest.

The table suggests that there is considerable variability in all of the characters studied among the pascal varieties grown. The variety 52-70H yielded significantly more than the lowest 16 varieties but not significantly more than the top six varieties.

For weight per stalk and petiole length, 52-70H was superior to all of the varieties tested. The data indicates that Pascal 137 and

TABLE 1—Yield and other characteristics of 23 celery varieties

Variety	Source	Yield per acre	Trim	Weight per stalk	Petiole length	Petiole	Dozens per crate				Aster yellows
							2	2½	3	4	
		(crates)	(percent)	(pounds)	(inches)	(number)	(percent)				(percent)
Utah 52-70H	Ferry-Morse (20372)	1080	40	2.4	11.3	14	70	18	11	1	9
Utah 52-70	Abbot & Cobb (376)	1052	40	2.3	9.6	12	79	13	7	1	13
Utah Jumbo	Grand Rapids Growers (295-J)	1035	39	2.3	8.4	14	65	29	6		15
Utah 15	Grand Rapids Growers (378-M)	1028	40	2.3	8.7	13	81	11	7	1	10
C-54-17	N.Y. Agr. Exp. Sta	1022	45	2.3	9.3	13	84	9	6	1	13
Improved Utah	Gunson	982	41	2.2	9.9	13	69	20	4	7	11
Utah 10B	Grand Rapids Growers (207-J)	962	36	2.1	8.3	14	85	11	1	3	6
Utah Pascal	Abbot & Cobb (527)	948	36	2.1	8.2	14	70	25	4	1	1
Green Lite	Harris	945	40	2.1	8.6	14	81	12	4	3	9
Pascal 137	Ferry-Morse (C-6441)	943	32	2.1	8.9	9	68	13	15	4	14
MSU 118	Mich. Agr. Exp. Sta	926	39	2.1	8.5	11	61	34	4	1	5
ES-55-43	Eastern States Farmers Exchange	902	41	2.0	8.0	10	64	19	13	4	13
New Tall Golden(*a*)	Grand Rapids Growers (443-L)	897	41	2.0	8.4	13	67	20	13	2	20
MSU 142	Mich. Agr. Exp. Sta	873	42	1.9	9.0	12	55	27	14	4	8
MSU Composite	Mich. Agr. Exp. Sta	866	39	1.9	8.5	12	65	27	7	1	6
B-56-136-D	Fla. Agr. Exp. Sta	861	40	2.0	8.2	12	54	24	14	8	8
C-54-19	N.Y. Agr. Exp. Sta	857	35	1.9	7.2	14	55	27	8	10	9
Cornell 19(*a*)	Grand Rapids Growers (182-L)	842	38	1.9	7.5	12	60	30	7	3	13
MSU 153	Mich. Agr. Exp. Sta	832	43	1.9	9.1	11	47	37	11	5	6
Utah 96	Ferry-Morse (C-6455)	813	45	1.8	9.3	12	58	24	15	4	5
Utah 13B	Ferry-Morse (33302)	803	37	1.8	8.0	11	53	31	8	8	6
C-54-29-2	N.Y. Agr. Exp. Sta	769	37	1.8	7.2	14	51	16	12	20	8
Golden Plume(*a*)	Grand Rapids Growers (209-J)	757	34	1.7	8.1	11	62	21	9	8	18
LSD	5 percent	129	5	.3	.7	1					
LSD	1 percent	168	7	.4	.9	2					

(*a*) Yellow.

ES-55-43 have fewer petioles than the other varieties which was clearly evident in their lack of heart development.

The percentage of aster yellows as indicated in the table was observed in a variety trial conducted at East Lansing. This may or may not be indicative of the tolerance of these varieties to this disease throughout the state.

OPTIMUM STRATIFIED RANDOM SAMPLING APPLIED TO ACRES PER FARM FOR BARRY COUNTY, MICHIGAN

By W. D. BATEN [1]

Introduction

Stratified random sampling was explained in this bulletin[2] (Baten, 1957) and was compared with random sampling; the data used were the number of acres per farm in Barry County, Michigan where the townships were the strata. This article presents a comparison of stratified random and optimum stratified random sampling for determining estimates of the average number of acres per farm in Barry County and estimates of the total number of acres in the county.

In the paper referred to, random samples were taken from each township to obtain an estimate of the number of acres per farm for Barry County. Ten and 5 percent of the farms of each township were taken as the stratified samples and the following formula was used to obtain an estimate for the average number of acres per farm:

(1)

$$\bar{y}_{st} = \Sigma H_h \bar{y}_h / N$$

where N_h is the number of farms in township h, $\bar{y}_h$ is the average of the 10 percent sample taken from township h, and N the number of farms in the county.

In optimum stratified random sampling Tschuprow (1923)[3] and Neyman (1934)[4] showed that the smallest standard deviations for the mean and totals were obtained when the size of the random sample from the hth stratum was equal to .

[1]Agricultural Experiment Station Statistician and Professor of Statistics Michigan State University, East Lansing, Michigan.

[2]Baten, W. D. (1957). Random sampling versus stratified random sampling applied to estimating the average number of acres per farm in Barry County, Michigan. Mich. Agr. Expt. Sta. Quart. Bul. 40: 250-255.

[3]Tschuprow, A. A. (1923). On the mathematical expectation of the moments of frequency distributions in the case of correlated observations. Metron, 2, 461-493 and 646-683 pp.

[4]Neyman, J. (1934). On the two different aspects of the representative method; the method of stratified sampling and the method of purposive selection. Journ. Roy. Stat. Soc. 97. 558-606 pp.

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(2)

$$n_h = nN_hS_h \;/\; \Sigma\, N_hS_h \quad ,$$

where S_h is equal to

(3)

$$S_h = \sqrt{\frac{\Sigma\,(x_{hi} - \bar{x}_i)^2}{N_h - 1}} \quad ,$$

where n is the size of the sample from the county, and S_h is the standard deviation of the hth township. For example, the number of random farms taken from the tenth township is, according to this formula,

$$n_{10} = (425 \times 277 \times 48.) \;/\; 224{,}021.13 = 25.$$

Since this township had 277 farms, 27 were taken for the stratified random sample and 25 for the optimum stratified random sample. Formula (2) was used to determine how many farms should be taken at random for each township for the optimum sample. Table 1 gives the number of farms taken from the two types of stratified sampling.

TABLE 1—Number of farms taken at random from the townships

Township	Stratified sampling	Optimum stratified sampling
1	32	30
2	28	23
3	26	26
4	30	26
5	30	31
6	28	26
7	25	24
8	26	28
9	28	27
10	28	25
11	26	33
12	18	30
13	26	28
14	29	27
15	29	25
16	16	16
	425	425

These values do not differ a great deal; in some cases the optimum numbers are smaller and in others they are larger. In both types of sampling there were 425 farms chosen from the county. These values of n_h depend upon the number of farms in the township, the standard deviations of the number of acres in the townships, and the number of samples taken from the county.

The estimate of the average number of acres per farm for the county for the optimum stratified sampling method is

(4)

$$\bar{y}_{opt} = \Sigma N_h \bar{y}_h / N ,$$

where $\bar{y}_h$ is the average of the optimum stratified sample from the hth township.

The standard deviation of this estimate is (Cochran 1953)[5]

(5)

$$\sigma (\bar{y}_{opt}) = \sqrt{[(\Sigma N_h S_h)^2 / \bar{n} - \Sigma N_h S_h^2]/N^2}$$

An estimate of the total number of acres for the county is equal to $N(\bar{y}_{opt})$ and an estimate of its standard deviation is equal to N times the above standard deviation.

Ten Percent Sampling

Table 2 contains these estimates for two 10 percent optimum stratified random samples.

[5]Cochran, W. G. (1953). *Sampling Techniques.* John Wiley and Sons, New York. 74 pp.

TABLE 2—Optimum stratified random sampling—10 percent sampling (acre)

	Universe known				When sample standard deviations are used in (5)	
	Estimate of the true average	Standard deviation of the mean	Estimate of the true total	Standard deviation of the total	Standard deviation of the mean	Standard deviation of the total
Sample 1.....	78.52	2.42	333,640	10,291	2.28	9,688
Sample 2.....	79.32	2.42	337,042	10,291	2.32	9,857

The standard deviation of the average for stratified random sampling was 2.47 acres which is a little larger than 2.42 acres obtained by optimum stratified random sampling.

For both types of sampling the estimated average size of a farm was well within two standard deviations of the true mean, showing that these two methods yielded excellent results.

Five Percent Sampling

Table 3 contains results from two 5 percent optimum stratified random samples.

TABLE 3—Optimum stratified random sampling—5 percent sampling (acre)

	Universe known				When sample standard deviations are used in (5)	
	Estimate of the true average	Standard deviation of the mean	Estimate of the true total	Standard deviation of the total	Standard deviation of the mean	Standard deviation of the total
Sample 1.....	83.50	3.52	354,792	14,956	3.39	14,404
Sample 2.....	81.86	3.52	347,823	14,956	3.50	14,872

The standard deviation of the estimates of the real average number of acres per farm for the 5 percent stratified random sampling was 3.61 acres; that for the optimum stratified random sampling was 3.52 acres, which is a little smaller.

Both methods gave good estimates of the true average. The 95 percent fiducial intervals for the real average include it, indicating that both methods of sampling led to rather accurate estimates.

THE EFFECT OF HARVEST METHOD ON THE YIELD AND MARKET VALUE OF ASPARAGUS[1]

By JOHN D. DOWNES

DEPARTMENT OF HORTICULTURE

SOME OF THE ADVANTAGES and disadvantages of harvesting asparagus by snapping rather than by cutting were pointed out by Barrons.[2] He reported that compared to cutting, harvesting asparagus by field snapping reduced harvest costs about 50 percent. It also greatly reduced the volume of waste handled and the labor required to prepare the raw product for processing. Further, it had no effect on yields the following year.

Carolus[3] reported that by 1949, 25 to 35 percent of all Michigan asparagus grown for canning was being snapped. In fact, processors were paying 80 to 100 percent more for snapped than for cut asparagus.

In the last 2 years of a 4-year trial period on a young planting, yields of edible product were about 16 percent higher from snapped than from cut plots. This increased yield may have been partly due to the fertilizer value of the stumps and to a reduction in injury to unemerged spears.

In 1956 it was felt that since the price being offered for snapped asparagus was only 53 percent greater than that being offered for cut spears, the two methods of harvesting should be revaluated. This would also offer an opportunity to learn how the length of the spear at harvest time, and the fern growth that sometimes appears on the stumps left after snapping affect production. In areas farther south and west, where temperatures during the harvest season are higher than in Michigan, snapping is not considered feasible because of the

[1]This project was supported by grants from the Southwestern Michigan Asparagus Growers Association and the Millburg Fruit Exchange.

[2]Barrons, Keith C. (1945). The field snapping method of harvesting asparagus. Mich. Agr. Expt. Sta. Quart. Bul. 28(2): 1-4.

[3]Carolus, R. L. (1949). Yield and quality of asparagus harvested by the field snapping method. Mich. Agr. Expt. Sta. Quart. Bul. 31(4): 370-377.

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excessive fern growth which results. This fern growth attracts beetles and is thought to depress the development of new spears.

METHODS

Comparisons were made of six harvesting practices (Table 1) in a field trial consisting of six replications of each practice arranged in a latin square. Each plot consisted of three rows 60 feet in length in a 7 year-old planting.

TABLE 1—Harvest methods

Designation	1956
A	Spears cut when 9-12 inches long, 2 inches below ground level
B	Spears cut when 7-9 inches long, at ground level
C	Spears snapped when 7-10 inches long, fern left on
D	Spears snapped when 7-10 inches long, fern removed
E	Spears snapped when 7-7½ inches long, fern left on
F	Spears snapped when 7-7½ inches long, fern removed
	1957
A	Spears cut when 7-12 inches long, 1 inch below ground level
B	Spears cut when 7-9 inches long, 1 inch below ground level
C	Spears snapped when 7-12 inches long, fern left on
D	Spears snapped when 7-12 inches long, fern removed
E	Spears snapped when 6-9 inches long, fern left on
F	Spears snapped when 6-9 inches long, fern removed

Fifteen harvests from May 16 through June 5 were made in 1956; and in 1957, 22 harvests were made from May 7 through June 5.

In 1956 cut spears were trimmed to 7 inches and the percent by weight of trimmed spear was recorded. In 1957, the butts were snapped by hand from cut spears and the weights of both the cut and the snapped product were recorded.

It was found that harvesting all spears in accordance with the initial plan in 1956 was impractical because 1 day's growth often produced spears that were longer than desired. Also, cutting spears at the ground level was much slower and less satisfactory than cutting about an inch below the surface.

No fern growth occurred on the stumps left by snapping. Thus, methods C, D, E, and F were essentially alike after the first few harvests in the first year.

The changes in 1957 in length of spear to be harvested (Table 1) were induced by practical considerations and by a change in the viewpoints of the industry with respect to length of spear desired.

In neither year was any fern growth encountered, perhaps because harvesting was terminated in early June while temperatures were still relatively low. Consequently, fern growth and removal cannot be considered a factor in this experiment.

However, relatively few growers in southwestern Michigan harvest asparagus much beyond the beginning of the strawberry harvest season because of competition for labor. It is only in fields where asparagus harvest is continued through June and perhaps into July that any appreciable fern growth occurs.

RESULTS AND DISCUSSION

The yields and corresponding market value for both years are summarized in Table 2.

TABLE 2—Yields and market value of asparagus harvested by six different methods (a)

Harvest methods	Yields (b) (lb./A.)		Market value (c) ($/A.)		1956+1957	
	1956	1957	1956	1957	Yield	Market value
A Cut.....	2386	3501	227	280	5887	507
B Cut.....	2181	3274	207	262	5455	469
C Snapped.....	1455	1950	211	263	3405	474
D Snapped.....	1583	2032	230	274	3615	504
E Snapped.....	1444	1868	209	252	3312	461
F Snapped.....	1363	1950	198	263	3313	461
LSD_{05}.....	230	230	NSD	NSD	194	NSD

(a) Harvest methods correspond to those in Table 1.
(b) LSD_{05} for differences between years within a method = 124 lb./A.
(c) 1956 cut = $0.095 per lb. Snapped = $0.145 per lb.
1957 cut = $0.080 per lb. Snapped = $0.135 per lb.

Since no fern growth was encountered and it was not practical to allow the spears to grow to the prescribed heights before beginning the harvest, the essentially different methods of harvesting with corresponding average yields and market values are summarized in Table 3. Methods A and B, C and D, and E and F of Tables 1 and 2 have been

TABLE 3—Yields (a) and market value (b) of asparagus for three harvest methods

	Methods (1957)			
	Cut to 7 inches (1)	Snapped to 7 inches (2)	Snapped to 6 inches (3)	Average
1956				
Yields lb./A.....	2283	1449	1473	1735
Value $/A.....	215	210	214	213
1957				
Yields lb./A.....	3387	1909	1991	2429
Value $/A.....	271	258	269	266
Totals				
Yields lb./A.....	5670	3358	3464	4164
Value $/A.....	486	468	483	479

(a) Yields: LSD_{01} for comparison of methods with a given year = 291 lb./A.
LSD_{01} for comparison of methods totals for the 2 years = 274 lb./A.
(b) Values: None of the differences are significant.
1956 prices paid: $0.095 for cut and $0.145 for snapped asparagus.
1957 prices paid: $0.080 for cut and $0.135 for snapped asparagus.

combined as indicated to form the methods designated 1, 2, and 3 in Table 3.

The yield of asparagus harvested in 1957 by cutting was 74 percent greater than that harvested by snapping. In 1956 the cut asparagus yield was only 56 percent greater than the average snapped yield. This differential response to method of harvesting was statistically significant and might suggest that there is some basis for the contention that snapping is associated with yield decline. However, the data presented cannot be considered conclusive evidence because different techniques in harvesting were used in the 2 years.

Yields converted to dollar value indicated no significance for harvest method. The average gross returns for 1957 were 25 percent above those of 1956, chiefly as a result of a longer harvest period in 1957. However, no significant difference in gross returns-per-acre as a result of different harvest methods was found in either year. Thus, snapping spears 6 inches or more in height gave the same yields and net returns as snapping spears 7 inches or longer.

The cut asparagus averaged 43.8 percent butts by weight when snapped shortly after harvesting. The percentage butts would possibly have been slightly higher by the time the asparagus reached the processing plant. Comparing the average yields of methods 1 and 2 for the 2-year period, the cut asparagus yield was 169 percent of the yield obtained by the snapped method.

With cut asparagus averaging 43.8 percent butts, the snapped asparagus equivalent of the cut product was 169 - (169 x .438) = 95 percent. Analysis of variance of the yields from field snapping compared to those obtained by snapping the butts off cut asparagus shortly after harvesting showed no significant differences. This indicated that the minimum spear length specified in the cut methods gave a usable product comparable in yields-per-acre to that obtained by direct field snapping.

Table 4 was constructed using the yield data from Table 3 and harvest cost data reported by Carncross[4] in New Jersey. It is apparent that snapping asparagus may provide greater net returns-per-acre than cutting. In order to obtain the same net returns-per-acre for the two methods, a grower would have to receive 11 cents per pound for cut asparagus.

A report from California[5] compares the cost of cutting an average 2,500 pound-per-acre yield with a newly developed cutting machine

[4]Carncross, J. W. (1956). What it costs to grow asparagus. N. J. Farm and Garden, Jan. 1956. p. 30.
[5]Kepner, Robert A. (1957). Improved asparagus harvester. Cal. Agr. 11(12): 4-6.

TABLE 4—Yields, harvest labor costs, and returns per acre from harvesting asparagus by cutting and by field snapping

Year	Harvest method	Yield lb./A.	Gross returns (*a*) $/A.	Harvest labor (*b*) costs $/A.	Net returns $/A.
1956	Cut to 7 inches.....	2283	216.89	84.47	132.42
	Snapped to 7 inches..	1449	210.11	42.24	167.87
	Snapped to 6 inches..	1473	213.59	42.96 (*c*)	170.64
1957	Cut to 7 inches.....	3387	270.96	125.32	145.64
	Snapped to 7 inches..	1909	257.72	62.66	195.06
	Snapped to 6 inches..	1991	268.79	65.35 (*c*)	203.44

(*a*) 1956 cut at $.095/lb., snapped at $.145/lb.
1957 cut at $.080/lb., snapped at $.135/lb.
(*b*) Assuming Barrons' estimate that costs of snapping are 50 percent of cost of cutting per acre, an average value of Carncross (1956) for harvesting by cutting (=$.037/lb.) with labor paid an average of approximately $1.00/hr.
(*c*) Harvest labor cost adjusted upward for higher yield.

to the cost of cutting by hand. Although the machine-harvested was only 55 percent of the hand-harvested yield, harvest costs were $10 per acre per season. This amounted to about one-tenth of hand-cutting costs. It is estimated that mechanical harvesting and hand cutting would yield the same net return-per-acre if the machine-harvested yield was 65 percent of the hand-cut yield.

Changes in labor costs, labor efficiency, machinery use, relative prices paid for cut and snapped asparagus, will all effect changes in net returns-per-acre. Increased use of labor field-transport machinery and the adaptability of snapping to such semi-mechanized harvesting methods suggest that cutting may be essentially eliminated in Michigan as a method of harvesting asparagus for processing.

SUMMARY

1. Cut asparagus produced about the same quantity of edible product per acre as snapped asparagus.

2. Asparagus cut almost daily from May 7 to June 5 to provide a spear no less than 7 inches in length was found to average about 44 percent butts by weight.

3. Although asparagus cut to 7-inch spears yielded 69 percent more than asparagus snapped at the same height, and 64 percent more than that snapped to 6 inches in height, gross returns per acre were not increased because of the price ratio of cut to snapped asparagus.

4. Snapping spears which were 6 inches or more above ground gave the same yields as snapping spears 7 inches or more above ground.

5. Data are presented which indicate that higher net returns per acre are obtained by snapping asparagus than by cutting it.

THE PRACTICALITY OF PLOWING FOR AND PLANTING CORN IN ONE OPERATION

A PRELIMINARY REPORT

By C. M. HANSEN, L. S. ROBERTSON and B. H. GRIGSBY[1]

DEPARTMENTS OF AGRICULTURAL ENGINEERING, SOIL SCIENCE, AND BOTANY AND PLANT PATHOLOGY.

TILLAGE COSTS account for about one-third of the farmer's corn production expenses. This includes seed bed preparation and cultivation. Because tillage costs represent a significant expenditure, any practice that reduces or eliminates the need for certain tillage operations should result in more efficient corn production. Work conducted by chemical weed control specialists shows that additional savings can be realized by using herbicides.

Minimum tillage methods are used by many Michigan farmers to cut production costs. Various adaptations of minimum tillage methods are effective in the different areas and on the diverse soils of the state.

The practical use of this principal involves doing a good job of plowing at the right soil moisture content. A small tillage tool is frequently attached behind the plow to level and firm the soil. The most successful results are obtained when the field is plowed and planted on the same day. The optimum soil moisture for plowing is also ideal for seed germination.

A study was conducted during the 1957 season in which the fertilizer was applied, the soil plowed, and the corn planted in one operation. This will be referred to in this paper as the "plow-plant" method.

DESIGN OF MACHINE

The machine used for the plow-plant research was assembled from standard component parts of several commercially available imple-

[1]The authors wish to express their appreciation to the Tractor and Implement Division of Ford Motor Company for the loan of equipment to conduct the research and to Augustine Almario, student, Agricultural Engineering Department, who gave much time to the execution of the research.

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Fig. 1. The application of fertilizer, the plowing, and the planting of corn were performed in one operation. Herbicides were applied after planting but no conclusive data were obtained as to their use.

ments (Fig. 1). These included (1) a 4-wheel, three-point hitch tractor equipped with an integral three 14-inch bottom plow, (2) a mounted corn planter, and (3) mounted planter or side dress fertilizer hoppers.

The fertilizer hoppers where mounted on either side of the tractor engine. The metering systems were powered by the tractor drive wheels through implement chains. A right-hand, front-mounted planter frame carried the one-row planter assembly.

Corn and starter fertilizer was placed in the crown of the center furrow which had been turned by a previous pass. The fertilizer dropped on the unplowed soil from the left-hand, front-mounted fertilizer hopper was under this furrow. The planter unit was raised and lowered by the tractor hydraulic system, which controlled the plow.

A 7 by 18-inch semi-pneumatic concave press wheel firmed the soil and eliminated air pockets under the turned furrow (Fig. 2). This wheel was turned 10 degrees toward the tractor to minimize side draft. This resulted in additional tillage as well as firmed soil. The pressure on this wheel was 525 pounds. The starter fertilizer was placed by a modified shoe 2 inches to the side and 2 inches below the seed and was deposited immediately behind the firming wheel.

Fig. 2. The planter unit included an integral soil firming wheel, starter fertilizer, applicator boot, seed hopper, seed furrow opener, seed presswheel, seed covering devices, and a final firming wheel. Pre-emergence sprayer equipment was given a limited test.

The seed shoe followed to the rear and to the side of the fertilizer shoe. A semi-pneumatic, soft rubber, 1 by 8-inch seed press wheel firmed the seed into the soil to accelerate germination. Approximately 1 inch of loose soil was brought over the seed immediately behind the seed press wheel by scrapers.

The planting operation was completed by a second 7 by 18-inch, semi-pneumatic press wheel which firmed the soil over the seed row. This second wheel also powered the seed metering mechanism as well as carrying a portion of the weight of the planter unit.

Nozzles were mounted at the rear of the final press wheel to facilitate the application of herbicides either in a band over the seed row, or over the entire soil surface.

The row width was adjustable from 42 to 38 inches by setting the plow to make a narrower cut with the right hand bottom.

EXPERIMENTATION

The unit just described was used on farms in Calhoun, Kalamazoo, Jackson, Eaton, Clinton, and Mason Counties, and on the university

farm in Ingham County. The plots reached across fields where farmers were planting corn. This afforded an opportunity to (1) obtain experience in operation under a number of soil conditions and (2) to grow corn that could be compared with that produced by the farmer who used either conventional or minimum tillage methods.

Some of the fields contained several soil types. The soils were surveyed to classify them and harvests were made in areas representative of specific soil types; hence several yields are reported from some of the fields.

Harvests were made from areas planted with the previously described equipment and from an adjacent area planted by the farmer with his own equipment and methods. In several cases the farmer used the minimum tillage principal and had fertilizer attachments on his planter which placed fertilizer in the soil in the recommended manner; 2 inches to the side of and 2 inches below the seed. In other cases, the farmer used conventional tillage methods which included plowing as a separate operation and subsequent tillage for seed bed preparation and planting.

At each location, diammonium phosphate (21-53-0) was used at the rate of 200 pounds per acre as a starter band of fertilizer. Muriate of potash (0-0-60) was applied from the fertilizer hopper on the left side of the tractor as a band on the surface of the unplowed ground. The potash was plowed down as a diffused band under the seed row on a subsequent trip across the field. The farmers used several different rates and grades of planting time fertilizer.

Two forms of herbicides were used to a limited degree. They were 2-4D and Simazin [2-chloro-4, 6-bis-(ethylamino)-S-triazine] which were applied at the rate of 2 pounds of active ingredient per acre. Treatments were made in a 10-inch band over the row and over the entire soil surface.

RESULTS

A comparison of the corn yields obtained from the experimental planter with the yields obtained from areas planted by the farmer are shown in Table 1. For the most part, yields represent single values obtained from nonreplicated treatments. No adjustments were made in stand after planting. This caused a variation in the plant population. This variation is not unusual for mechanically planted seed, but it significantly influenced corn yields.

TABLE 1—A comparison of corn yields and stands obtained from plow-plant and conventional tillage methods

County	Farm	Soil series	Bushels per acre		Plants per acre	
			Plow-plant	Conventional	Plow-plant	Conventional
Mason	A	Iosco	82.9	52.0	19,505	15,355
Clinton	B	Brookston	105.2	88.3	16,174	14,347
Kalamazoo	C	Kalamazoo	70.7	46.3	11,721	13,263
Eaton	D	Conover	96.5	95.2	16,237	13,804
Eaton	D	Brady	128.6	108.0	19,808	14,044
Eaton	D	Miami	87.0	81.1	14,692	13,164
Eaton	E	Celina	30.7	25.6	12,974	13,147
Eaton	F	Miami	68.2	58.9	16,133	14,135
Eaton	F	Eroded Miami	62.0	40.3	12,529	8,887
Eaton	F	Houghton Muck	93.0	49.6	17,006	12,907
Eaton	G	Hillsdale	64.5	59.3	14,000	14,000
Eaton	G	Eroded Miami	69.2	69.2	14,000	14,000
Eaton	G	Miami	65.8	76.6	14,000	14,000
Ingham	H	Hillsdale	74.3	60.1	15,874	16,322
Jackson	I	Boyer	68.9	72.0	15,272	11,822
Jackson	J	Hillsdale	77.4	83.3	13,010	15,985

Small differences at a given location probably reflect variations other than the malfunction of the planter equipment or methods of seeding. Care was not always exercised in cultivating. This is particularly true where the corn was planted on the contour, a system which did not make for uniform row width with the experimental planter.

Yields varied from field to field. Average per acre yields from the plow-plant plots were 11 bushels higher than from the conventional tillage plots. A statistical analysis of these data using fields as replications shows that the plow-plant method of growing corn resulted in higher yields than were obtained in the same field with those methods used by the farmer. This is significant because several of the farmers used the minimum tillage method.

The yields obtained by the plow-plant method on the Brady soil on farm D are especially important. The alfalfa sod had been pastured for a number of years. A particularly poor job of plowing was done

because general purpose moldboards were used instead of sod moldboards. This is not to imply that the need for a good job of plowing should be disregarded with this method of planting corn, but rather that high yields were obtained even under these extreme conditions.

The corn on farms B and D was never cultivated. The corn on the other farms was cultivated either once or twice. It may not have been necessary to have cultivated the corn planted with the plow-plant equipment for weed seeds do not readily germinate on loose soil. However, no difficulty was experienced in cultivating the corn where it was not planted on the contour. It was possible to delay this operation longer than usual and cultivate without shields with the row shovels or sweeps set further from the row.

The work conducted during the 1957 season in which herbicides were applied with the plow-planter should be considered exploratory. These plots did not lend themselves to statistical analysis; thus the results should be considered inconclusive.

SUMMARY

An experimental machine was designed and assembled to facilitate plowing for and planting corn in one operation. The implement was used at eleven locations. Corn yields harvested from plots where the implement was used averaged 11 bushels per acre higher than corn grown in the same field that had been produced by the cooperator with his conventional tillage methods, planting equipment, and fertilizer rates. A marked reduction was noted in the weed population where the corn was planted with the plow-plant machine.

FUTURE RESEARCH

More extensive research needs to be conducted with the use of herbicides applied at planting time at varying rates. A comparison of yields with controlled rates of seeding and fertilizer application should be made. It will be desirable to conduct time studies of the conventional and plow-plant systems in the production of corn as well as consider the costs of equipment used by the two planting systems.

STABILITY AND DURABILITY OF UNDERDRAINS IN AN ORGANIC SOIL

By R. Z. WHEATON, E. H. KIDDER and W. A. CUTLER[1]

DEPARTMENT OF AGRICULTURAL ENGINEERING

A TILE DRAINAGE SYSTEM was installed at the University Muck Experimental Farm in the early 1940's. Provision was made for removal of water by pumping. Tile laterals were installed to provide profile drainage and sub irrigation by water table control. The maintenance of a high water table reduces the rate of subsidence.

Plans for the expansion of the cultivated area in 1951 provided an opportunity to place additional tile laterals to study the effect of various materials and practices.

Four laterals were installed in June, of 1952, to determine (1) the stability of tile laterals in organic soils, (2) the durability of concrete tile, perforated galvanized steel pipe, and perforated fibre pipe in these soils, and (3) the subsidence of the soil surface following drainage. A control gate was placed in the main in 1957 to better regulate the water table in this newly developed area.

The soil in the area of this experiment is described as Houghton muck. The profile consists of (1) a surface layer of 6 to 8 inches of finely divided black muck, (2) a subsurface layer of 8 to 36 inches of reed sedge peat with a few Tamarack roots and some other woody materials, and (3) a substratum layer 36+ inches of coarse fiber material with slight decomposition.

The tile were placed in the latter peaty material. The laterals were spaced 60 feet apart and each is approximately 750 feet in length. Shale tile 6 inches in diameter and 2 feet in length were used throughout with the exception of the durability experimental sections which are located at the upper end of each lateral (Fig. 1).

Concrete tile 6 inches in diameter and 1 foot in length, from two manufacturers, were placed on the upper end of lateral No. 1. Other

[1]The authors wish to acknowledge the assistance of J. F. Davis, L. N. Shepherd and R. M. Gillespie of the Soil Science department.

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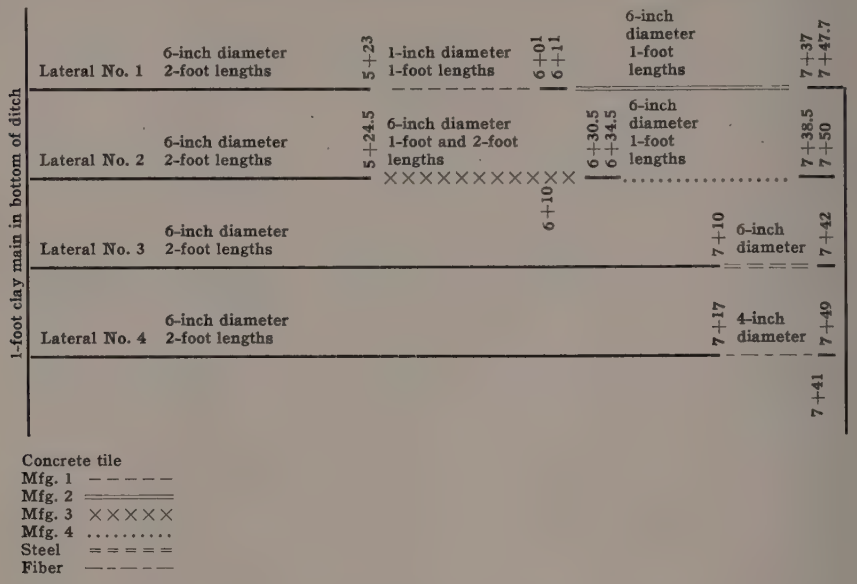
Fig. 1. Tile system showing location of durability test sections.



concrete tile 6 inches in diameter and 1 and 2 feet in length from a third manufacturer; together with concrete tile 6 inches in diameter and 1 foot in length from a fourth manufacturer were placed at the upper end of lateral No. 2.

Samples of the concrete tile from each manufacturer were tested for strength and absorption according to ASTM specifications C4-50T. Thirty-two feet of perforated, galvanized pipe, 6 inches in diameter, was installed at the upper end of lateral No. 3. Twenty-four feet of perforated, bituminous-fibre pipe, 4 inches in diameter, was installed at the upper end of lateral No. 4.

Varying thicknesses of dry marsh hay blinding were placed over part of the laterals. The elevations of the top of the tile lines at 20-foot intervals were determined and recorded immediately after installation.

The elevations of the top of the tile lines are redetermined annually at 20-foot intervals by use of standard surveying equipment and tile probes. Soil surface elevations are obtained yearly at 100-foot intervals and at a point offset 10 feet to the north of each tile line.

In accordance with initial plans, a 4-year interval detailed examination was made on November 8, 1956. Two feet of concrete tile were

removed at three stations for each of the four concrete manufacturers represented. These tile were photographed prior to being tested according to ASTM C4-55 specifications for strength and absorption.

The perforated steel and fibre pipes were examined for evidence of deterioration. The various thicknesses of marsh hay used for blinding the tile were examined for deterioration. The accumulation of sediment in the tile at each location was noted.

RESULTS

A yearly plot of the elevations of the soil surface and top of the tile elevations for lateral No. 4, which is typical of the other three laterals, is shown in Fig. 2.

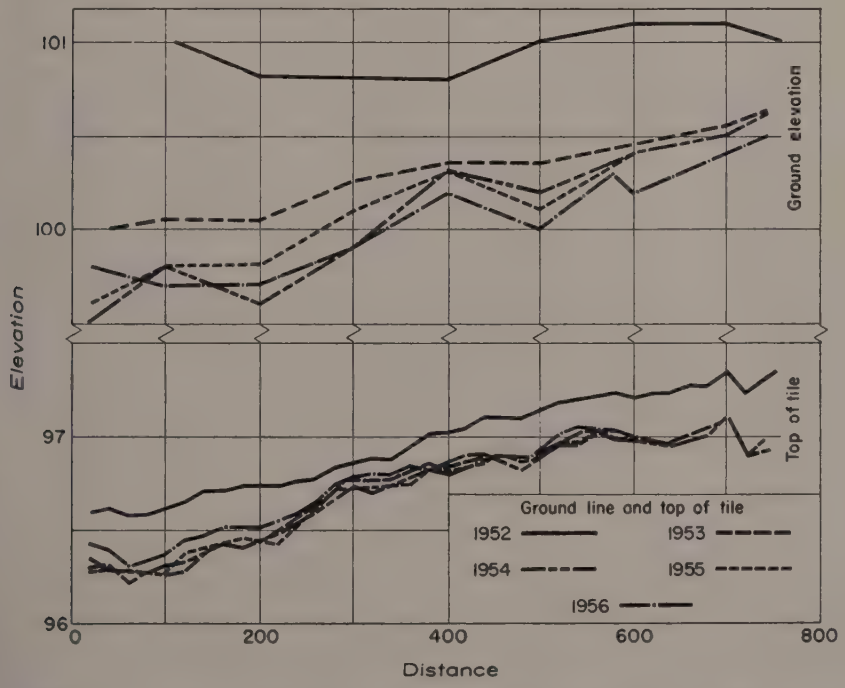


Fig. 2. Ground surface and top of tile elevations lateral No. 4, 1952 through 1956.

Fig. 2 shows a soil surface subsidence of about 0.8 to 0.9 foot between stations 0 + 00 and 5 + 80[2] during the first 2 years following

[2]Stations are referenced in terms of 100-foot intervals from the point of outlet, hence station 5 + 80 is 580 feet from the outlet.

tile drainage, with little or no subsidence the following years. The area from station 5 + 80 to 7 + 50 remained in blue grass sod until the spring of 1956. This area subsided about 0.6 foot during the first 2 years following drainage and an additional 0.1 to 0.2 foot from November, 1955, to November, 1956.

The tile elevations show a subsidence of about 0.3 foot the first year following installation with negligible elevation changes during the following years. The apparent greater depth from station 7 + 20 to the end of lateral No. 4 results from the use of 4-inch diameter fibre pipe and 4-inch tile; the remainder of the lateral utilizes 6-inch diameter shale.

The tile elevations for the first 540 feet of the lateral in 1956 appear to be above those of previous years. Some 6.23 inches of rainfall in 35 days preceding these measurements on August 28 may have caused a swelling of the muck.

The August 28 elevation of temporary bench mark tree, which is located in the northwest corner of the research area, was .05 foot above its elevation on November 8 when the remainder of the elevations of the laterals were taken. Each time that a survey is made, the elevation of this temporary bench mark is re-determined in reference to the permanent bench mark.

With the exception of the original elevations during installation in June, 1952, and those of August 28, 1956, all the elevation measurements have been made on or about November 8.

TABLE 1—Durability of concrete tile in organic soil[3]

Manufacturer	Original		After 4 years	
	Strength	Percent absorption	Strength	Percent absorption
1	1237	7.0	1021	9.0
2	1125	7.0	1279	8.7
3	1062(a)	6.5	1698 (a)	7.6
4	1000	8.3	732	10.5

(a) It is believed that the original 1-foot lengths of tile supplied for testing were not representative of the special 2-foot lengths of tile which were placed in the soil.

[3]The pH of the soil at the tile depth ranged from 6.4 to 6.6.

Table 1 gives the average strength and absorption of the four concrete manufacturers' tile before installation and after 4 years in the organic soil. The tile of the third manufacturer shows an apparent

increase in strength; however, it is believed that the original 1-foot lengths which were supplied for testing were not representative of the special 2-foot lengths of tile which were placed in the soil.

The concrete tile of the fourth manufacturer no longer met the standard quality specifications. The concrete tile supplied by the first and second manufacturers declined in grade from extra quality to standard in 4 years, while those of the third manufacturer still met specifications for extra quality concrete tile.

Examination of the concrete tile before testing showed that most of the etching and/or internal pitting was on the sides of the tile with little, if any, etching and pitting on the top and bottom quarters of the tile. Many specimens showed considerable etching on the side walls and showed none whatsoever on the bottom quarter of the tile (Fig. 3). The pH of the soil at the tile depth ranges from 6.4 to 6.6.

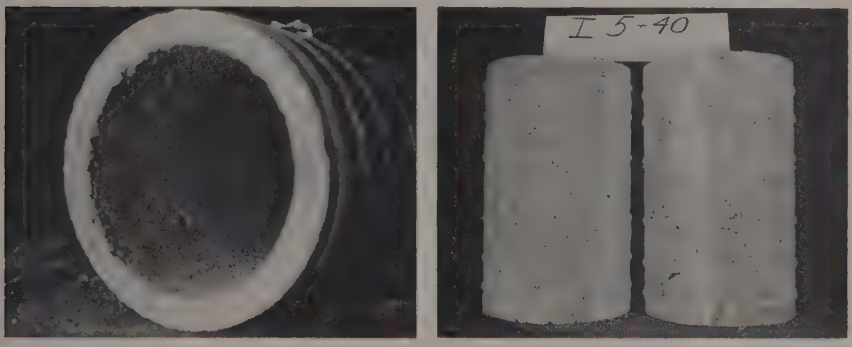


Fig. 3. Acid etched concrete tile. Left, interior view of acid action. Right, bottom quarter (white) shows least etching.

The perforated steel and fibre pipe appear to be functioning satisfactorily. Considerable rusting was observed on the galvanized steel pipe. Internal diameter measurements of the bituminous fibre pipe showed a slight oblateness in that the horizontal dimension was 0.1 inch greater than the vertical dimension.

The marsh hay used for blinding material during installation was in excellent condition. At many stations, it retained its original green color. In the areas where depths of 18 to 24 inches of loose hay were placed over the tile, an excessive amount of hay still remained in the trench.

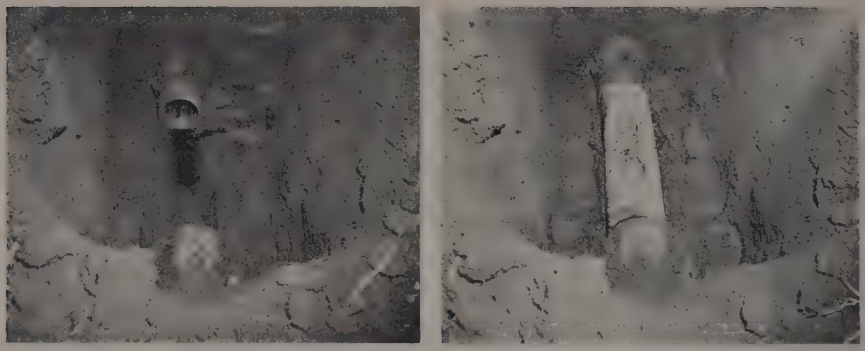


Fig. 4. Marsh hay blinding. Left, tile removed showing no sediment accumulated in blinded line. Right, replacement tile in place, note 2-inch depth of hay.

Fig. 4 shows that 1½ to 2 inches of compressed hay blinding material which remained over the tile at station 7 + 15 on lateral No. 2. This thickness of hay was found to exist at several stations where average depths of 6 inches of loose hay were placed over the tile during installation.

CONCLUSIONS

1. The soil surface subsided 0.8 to 0.9 foot the first year following drainage with little or no subsidence the following 3 years.
2. The tile settled about 0.3 foot the first year following drainage with negligible changes in the next 3 years.
3. Three out of the four manufacturers' concrete tile show definite deterioration in quality in 4 years.
4. Considerable rusting was observed on the galvanized steel pipe.
5. A slight oblateness of the bituminous fibre pipe was noted.
6. The hay blinding material remained in excellent condition for 4 years.

CALCIUM CHLORIDE FOR MOISTURE ABSORPTION IN CORN STORAGE

By CARL W. HALL[1]

Department of Agricultural Engineering

INTRODUCTION

One-third to three-fourths of a million bushels of corn were carried over from one storage year to the next from 1950 to 1956. Research work has been devoted primarily to the methods of maintaining storage quality for 1 year or less without much attention to long-time storage.

One of the biggest storage problems is moisture movement which occurs in stored grains. In the northern areas of the United States, the moisture accumulates in the top layer of stored shelled corn. As the temperature variation and time of storage increases, the amount of moisture migration increases. Corn is usually turned periodically to prevent spoilage by moving it either within a bin or from one bin to another.

Fans driven by electric motors provide an excellent method of protection for stored grain. This requires electrical service, however, which often is not available at bin sites.

A practical method is needed to prevent excess moisture accumulation in the top layer of corn. Because of the low cost and availability of calcium chloride, studies were made using calcium chloride to absorb the moisture in the surface layers of the stored corn.

OBJECTIVE

The major objective was to determine the effectiveness of and the suitable procedures for using calcium chloride to maintain a safe moisture content in shelled corn stored longer than 1 year.

[1]The author wishes to acknowledge the AMS and CCC of the USDA for financial support of the project (A1 Graf, coordinator), the Michigan and Clinton County ASC committee for furnishing facilities and cooperating in making arrangements, and the Dow Chemical Company, Midland, Michigan for furnishing chemicals.

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PROCEDURE

Cylindrical steel bins containing 3,200 bushels of shelled corn were used during 1955 and 1956 for the tests. These bins, commonly used for storage by the Agricultural Stabilization and Conservation Committee, are 18 feet in diameter and 15 feet high. They are not normally provided with means of aerating the grain. Air movement can take place across the top of the grain through openings between the top of the bin and the roof and through a circular ventilator in the peak of the roof. Air intake openings are not provided at the bottom of the building.

Several experiments were conducted over a 2-year period to determine the value of pellet and lump forms of calcium chloride placed in rectangular and cylindrical containers:

1. **Rectangular containers above the grain.** Three rectangular containers 1.5 feet by 6 inches by 2 feet (length by width by height) were

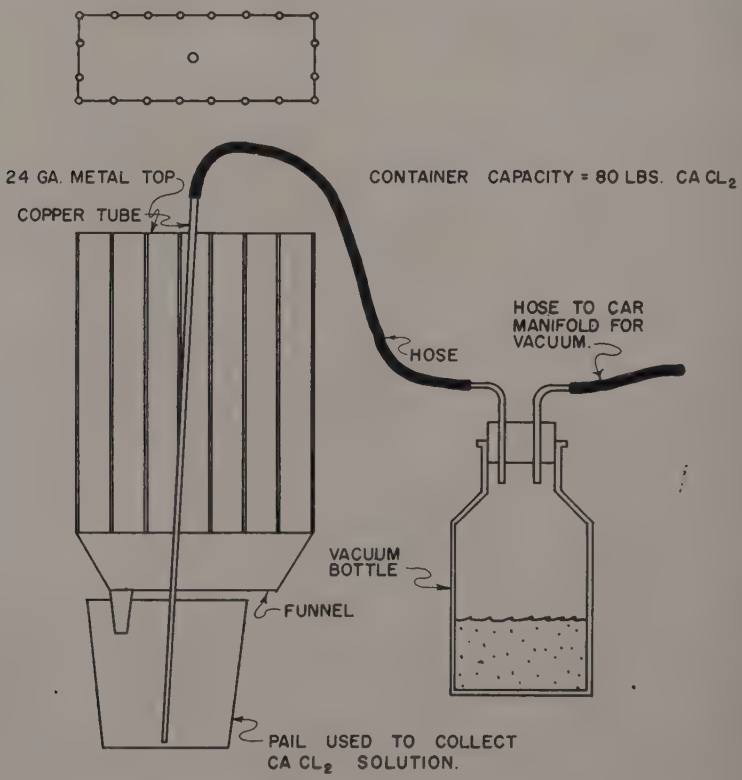

Fig. 1. Rectangular container and method of draining.

placed in the top of a bin between the roof and the grain. The three containers were placed 7.5 feet apart equidistant from the center of the bin and formed the corners of an equilateral triangle.

Each container was constructed of ¼-inch diameter steel rod welded together, a funnel, a pail, and copper tubing. Plastic screen was placed on the inside and outside of the metal framework (Fig. 1). A funnel was attached to the bottom of the container to catch the calcium chloride solution and a pail was placed under the funnel to collect the solution. Calcium chloride solution was removed from the bucket through a copper tube which extended to the bottom of the pail from a point above the container.

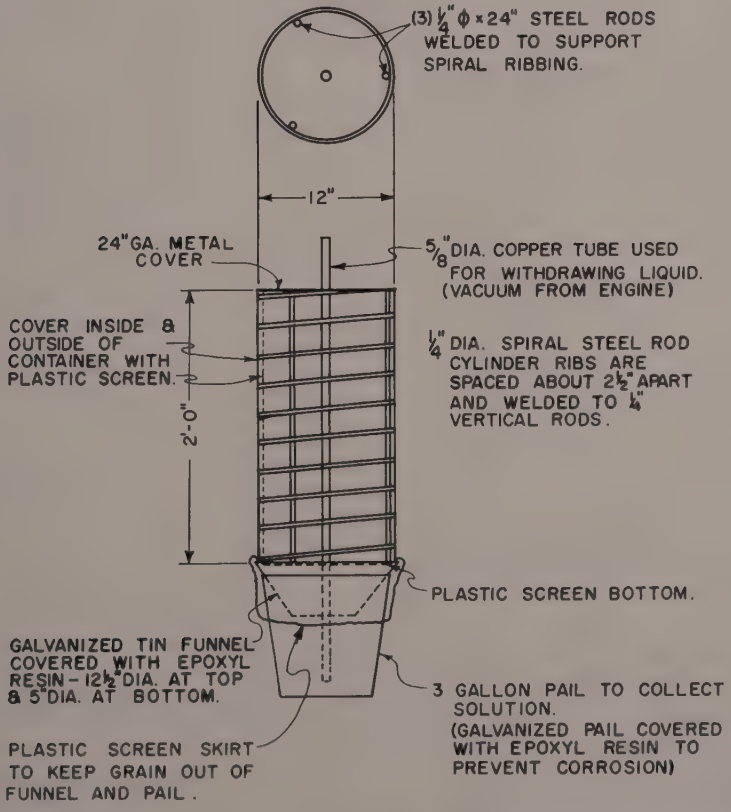
(3) ¼" ϕ x 24" STEEL RODS WELDED TO SUPPORT SPIRAL RIBBING.
12"
24"GA. METAL COVER
⅝" DIA. COPPER TUBE USED FOR WITHDRAWING LIQUID. (VACUUM FROM ENGINE)
COVER INSIDE & OUTSIDE OF CONTAINER WITH PLASTIC SCREEN.
¼" DIA. SPIRAL STEEL ROD CYLINDER RIBS ARE SPACED ABOUT 2½" APART AND WELDED TO ¼" VERTICAL RODS.
2'-0"
PLASTIC SCREEN BOTTOM.
GALVANIZED TIN FUNNEL COVERED WITH EPOXYL RESIN - 12½" DIA. AT TOP & 5" DIA. AT BOTTOM.
3 GALLON PAIL TO COLLECT SOLUTION. (GALVANIZED PAIL COVERED WITH EPOXYL RESIN TO PREVENT CORROSION)
PLASTIC SCREEN SKIRT TO KEEP GRAIN OUT OF FUNNEL AND PAIL.

Fig. 2. Round container used to hold calcium chloride (capacity 80 lb.).

An automobile manifold was used to obtain a vacuum in a 1 gallon glass bottle. A hose was connected to the bottle to withdraw the calcium chloride solution from the pail.

The same method of collecting the solution was used for all containers.

2. **Cylindrical containers above the grain.** Three round containers, 1 foot in diameter and 2 feet high, were constructed of the same materials as the rectangular containers (Fig. 2). The cylindrical frame was constructed of ¼-inch diameter steel rod and covered on the inside and outside with plastic screen. A funnel, pail, and copper tube completed the unit. These containers were placed in the same position as the rectangular units. Each cylindrical container had a capacity of 80 pounds of calcium chloride.

3. **Rectangular containers in the grain.** Three rectangular containers, constructed as described under Procedure 1, were placed in the grain so that the top of the containers were flush with the surface of the shelled corn.

4. **Cylindrical containers in the grain.** Six cylindrical containers, constructed as described under Procedure 2, were placed in the corn so that the top of the containers were flush with the surface of the corn. The locations of the containers are shown in Fig. 3. Five con-

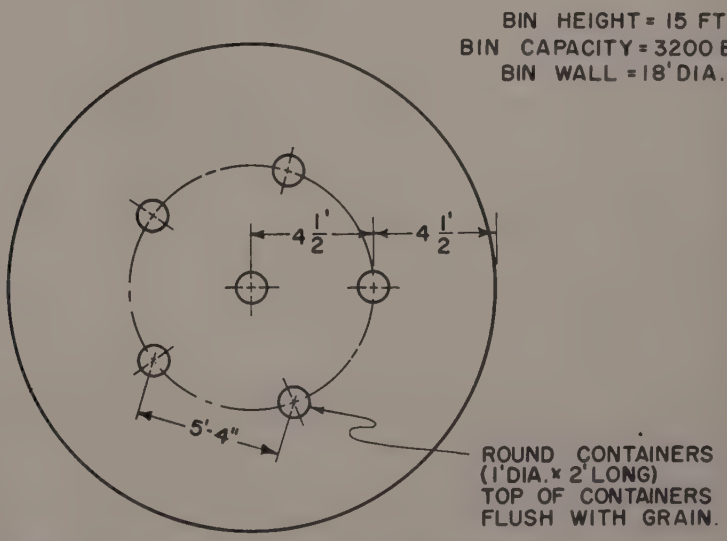

Fig. 3. Location of six round containers in bin of shelled corn.

tainers were placed 4½ feet from the edge of the bin, evenly spaced inside the bin, and one container was placed in the center of the bin.

The galvanized 12-quart pail which was used for collecting the calcium chloride solution, was coated with epoxyl resin to prevent corrosion. Data were obtained on the performance of the various installations including weight of calcium chloride used, weight of solution collected, and moisture content at various depths and distances from the calcium chloride charge. The temperature and grade analyses were determined periodically throughout the tests. The most satisfactory arrangement was repeated for an additional 1 year test.

Considerable time was spent in sampling and in determining moisture content to obtain representative samples throughout the bin. Representative samples can be obtained in a 3,200 bushel storage bin by sampling a ring between 4 and 5 feet from the center of the bin to a depth of 1 foot for one sample and from 1 to 2 feet for another sample. As recommended by the project cooperator, on the basis of previous research, a sample was obtained 10 feet below the surface in the center of the bin to obtain the average moisture content of the grain below 2 feet.

DATA AND RESULTS

There was no advantage in placing rectangular or cylindrical containers with calcium chloride above the grain. Since the tops of these bins were not sealed, air from the atmosphere had access to the containers and the calcium chloride collected considerable moisture from the atmosphere rather than from the corn. The moisture content of the top 6 inches of grain in the bins equipped with three containers above the grain was 18 percent; the control bins averaged 17.9 percent. The moisture in the remainder of the bin was 14 percent.

Three rectangular containers in the shelled corn permitted the moisture content to increase 4 percent in the top 6 inches at the center. Three rectangular containers in the top 2 feet of grain did not give satisfactory control of moisture.

With six cylindrical containers in the grain, the moisture content of the top 2 feet of grain showed a lower value than the controls in all five storages, but did not prevent moisture accumulation in bins with a moisture content over 14 percent.

Experiments were run for an additional year using six round containers in the grain to verify the results. When the containers were installed in corn having a moisture content of 13.5 percent or lower,

the calcium chloride maintained the moisture content near that level. A consistently high moisture content persisted in the top 6 inches of the control bins. The bins containing six calcium chloride containers showed a definite trend toward maintaining or reducing the moisture content of the top 6 inches. The top 6 inches of the control bins were from 2 to 5 percent above the original moisture content and above the moisture content of the top 6 inches in the bins with calcium chloride.

In 1 year, approximately one-fourth or 120 pounds of the calcium chloride in the six containers were dissolved in absorbing the moisture in bins originally at 13.5 percent moisture.

One filling of the containers should protect the grain over a period of from 2½ to 4 years, depending on the weather conditions. During that time the solution must be removed periodically from the buckets to prevent it from spilling in the grain. Or, a large container may be used for collecting the salt solution.

Pellet size calcium chloride was superior to the lump form because the materials remained more porous. After preliminary tests, pellet calcium chloride was used for all of the tests with six containers in the surface of the bin.

In a few cases, the moisture content of the grain increased adjacent to the container of calcium chloride where the moisture content normally would be expected to be the lowest. The higher moisture content might be due to more rapid temperature change of the grain next to the container and would occur when the outside air is colder than the grain mass. Thus, the temperature of the grain would decrease and the moisture content increase for a particular relative humidity.

Based on labor charges of $1.00 per hour, the cost of installing and maintaining one calcium chloride container with calcium chloride, based on a 4-year life, was $2.76 per container per year; and based on an 8-year life, $1.80 per container per year.

The following recommendations are made for installing a calcium chloride system for protecting the top 2 feet of shelled corn at 13.5 percent moisture content or lower stored in a 3,200-bushel cylindrical bin:

1—Six cylindrical containers should be placed in an 18-foot diameter bin to protect the shelled corn.

2—The copper tubes used to drain the collector pails of the calcium chloride solution should be straight and have at least a ⅝-inch diameter.

3—All galvanized metal and ferrous metal parts used should be covered with epoxyl resin to prevent corrosion.

4—Calcium chloride containers should be installed when the bins are filled. If it is necessary to install containers in bins that have already been filled, the following procedure has been found satisfactory: (1) Force a 13-inch diameter pipe into the corn, (2) remove the corn from the inside of the pipe; perhaps using a vacuum unit, and (3) insert the calcium chloride container inside of the pipe, then remove the pipe.

5—Screen used in making the containers should be made of plastic to prevent corrosion. A piece of plastic screen 6 inches wide should be placed around the container just above the edge of the funnel to prevent shelled corn from getting into the solution collector pail.

6—The pail should be drained at least twice a year to prevent overflowing. One draining of the solution pail should be made in the fall to prevent crystallization of the calcium chloride in the pail; the other draining can be done in the spring.

CONCLUSIONS

1. In 1955 and 1956 in Michigan, six containers of calcium chloride in the top of a 3,200-bushel shelled corn storage bin kept the moisture content below 14 percent when the moisture content of the corn was initially 13.5 percent or less at the time the containers were installed.
2. Placing calcium chloride above the grain where there is an interchange of air from the outside does not prevent moisture accumulation in the surface of the grain.
3. Pellet-type calcium chloride was superior to the lump-type.
4. Less than six calcium chloride containers per bin, each container holding 80 pounds, was not satisfactory in preventing moisture accumulation in the surface of the grain.
5. The annual cost of operation for one container based on a 4-year life is approximately $2.76. Protection is provided for the upper 2-foot layer of shelled corn.
6. By coating ferrous metal parts with epoxyl resin plastic and using plastic screen for covering the metal framework, the container and collecting pail did not deteriorate. The calcium chloride did not damage the shelled corn next to the container.

COMPARISON OF VIRUS-FREE STOCKS OF STRAWBERRIES WITH STANDARD COMMERCIAL PLANTS

By J. E. MOULTON, R. H. FULTON, H. K. BELL, and R. F. CARLSON

Departments of Horticulture and Botany and Plant Pathology

THE DEGENERATION or running out of strawberry varieties has been observed almost from the beginning of their commercial cultivation. On the basis of evidence accumulated since the first report by Plakidas (1926) of a virus disease of strawberries in this country, it appears that much of the decline observed in strawberry varieties can be attributed to viruses.

Demaree (1950) and Demaree and Marcus (1951) showed that strawberry stocks in Eastern United States are generally infected with virus. The symptoms and severity of virus diseases vary with the variety of strawberry and the type of virus present. Some varieties, like Premier, show no obvious symptoms when infected with yellows virus. Others like Catskill may show yellowing, cupping of the leaves, and severe stunting.

Research workers in the United States Department of Agriculture at Beltsville, Maryland began an intensive search in 1946 for virus-free plants. At last report, 36 varieties of strawberries from this source are substantially free of aphid-borne virus. In 1950, a similar program in cooperation with the U.S.D.A. was initiated in Michigan. At present, 31 virus-free varieties are being maintained, of which Catskill, Marshall, and Robinson are now available to growers from several Michigan nurseries.

The availability of these virus-free stocks raises the question of superiority of specific virus-free varieties compared with ordinary commercial plants.

Braun (1955) in New York, Hill and Gould (1955) in Ohio, Becker and Rich (1951) in New Hampshire, and Craig (1957) in Canada all reported that virus-free plants of Premier, Sparkle, and Catskill were superior in runner production and yields to plants not free of virus.

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Zeller (1933) found that virus-free Marshall produced over twice as much fruit as Marshall plants infected with crinkle.

In view of these reports of the superior performance of certain virus-free varieties in other states, it seemed desirable to conduct field tests in Michigan to compare healthy stocks of Robinson, Premier, and Catskill, the principal varieties grown in this state, with locally grown commercial strawberry plants.

MATERIALS AND METHODS

Substantially virus-free plants of the varieties Premier and Catskill were obtained in March, 1954 from a nursery in Delaware, while virus-free Robinson was from a stock of plants isolated by R. H. Fulton at East Lansing, Michigan. A local nurseryman supplied the standard commercial stock.

Plants from both sources were taken at random and checked for possible virus infection. Using the method described by Miller (1952), no virus was found in the substantially virus-free plants, while in the commercial stock yellows type (Latent C) virus was predominantly present.

The experimental plots were on a soil classified as Hillsdale sandy loam. Green manure crops were grown on this land for 2 years preceding the strawberries. The soil was treated prior to planting with 10 pounds of actual chlordane per acre for the control of white grubs.

Matted rows, 200 feet long, were established from mother plants which were set on April 7th with a spacing of 2 feet in the row and 4 feet between rows. One-half of each row consisted of virus-free stock and the other half of commercial plants of the same variety. Virus-free plants in a given row were paired with commercial plants of the same variety in an adjacent row. Each treatment was replicated four times.

Insects were controlled by spraying with parathion at 10-day intervals to reduce the possible spread of virus from the commercial stock into the virus-free plots. A side dressing of a 12-12-12 fertilizer was applied in June at the rate of 500 pounds per acre.

The total number of runners produced by August, 1954 was determined for each plot. The rate of runner initiation early in the season is important since, in general, runner plants established early produce much more fruit than later ones. The plants were allowed to run freely and no effort was made to control their spacing. The density of plant stand was measured the following spring by counting the

total number of plants lying within a frame 1 foot square placed at random at three different points in each plot.

The harvest season extended from June 9 to June 29, 1955 for Premier. The first picking was one week later for Catskill and Robinson. The fruit was harvested from each plot three times a week and weighed.

EXPERIMENTAL RESULTS

Catskill

By August 1, 1954, differences in vigor and rate of runner production between virus-free and common stocks of Catskills were pronounced, even though the mother plants from the different sources were alike in appearance at the time of planting. Virus-free plants had produced an average of 88 runners per plot compared to 47 runners for the standard stock (Table 1).

TABLE 1—Production of runners and yields of virus-free compared to standard stocks of Catskill, Robinson, and Premier strawberries

Variety	Number of runners per plot 8-1-54	Plants per square foot 4-1-55	Yield in quarts per acre
Catskill (standard stock)	47	10	4200
Catskill (virus-free)	88	12	4320
Robinson (standard stock)	234	13	1920
Robinson (virus-free)	254	16	2060
Premier (Michigan standard stock)	170	10	5664
Premier (virus-free from East)	109	15	5184

The greater vigor of the virus-free plants was evident, even when plots were viewed from a distance. The leaf petioles of the common stock were relatively short, while the leaves of the healthy stock were more upright and uniform without the uneven up and down appearance, as shown in the plots of common plants (Fig. 1).

Plant density counts for Catskill made in the spring of 1955 revealed that the virus-free plots had 20 percent more plants than the check plots. Solid rows were not obtained with standard commercial plants because of lack of vigor rather than from the death of any of the mother plants.

Fig. 1. Virus-free row of the Catskill variety on the left; and row of standard stock on the right. Note the much greater vigor and runner production of healthy plants on the left.

Fig. 2. Rows established from standard stock of the Robinson variety (left center) and virus-free stock (right center) showing the similarity in appearance of the two types of plants.

Robinson

In contrast to the superiority of virus-free Catskill in runner production, it was found that by August of the first growing season, virus-free plants of the Robinson variety produced only 8 percent more runners than the common stock. It is doubtful if this difference has any practical significance (Table 1).

Plants from both sources had excellent vigor, as shown in Fig. 2. This variety has a tendency to produce too many plants for highest yields in uncontrolled matted rows, especially where the mother plants are 2 feet apart in the row.

Premier

Observations made on the virus-free Premier plants, originally from Beltsville, indicate that this is a strain distinct from the Premier variety widely grown in Michigan in both foliage and fruit characteristics. The leaves of the plants from the East were lighter in color, and the leaflets were longer than in the local stock. Also, the fruit of the former was lighter in color and perhaps less firm, but no differences were noted in size or shape of fruit. The berries are lighter in color and softer than desirable for processing by freezing.

In runner production, the local common stock was superior in the first part of the season, but the virus-free stock from the East continued to grow vegetatively in September after the other strain ceased producing runners. The final result was that the virus-free plants ultimately led the common stock in total runner production (Table 1).

In this instance, different strains were being compared rather than the effect of virus on a specific variety.

Yields of Fruit

There were no differences in production between virus-free and standard plants of Robinson and Catskill, but the common strain of Premier was slightly more productive than the other strain. Yields, however, were greatly reduced in all cases by freezing May 9th. The temperature went to 20° F. when the plants were in full bloom following unusually warm weather in April.

Differences in yield were observed when varieties were compared. These differencs were apparently an expression of the inherent resistance of the varieties to frost. Premier, which is recognized for its resistance to frost, produced almost three times as much fruit as Robinson. Catskill was more than twice as productive as Robinson.

DISCUSSION AND CONCLUSIONS

Important factors in determining yields of a given variety of strawberries are the time and rate of production of runner plants and, also, their final number and spacing. Maximum production is realized only when the optimum number of runner plants is established early in the season.

Standard stocks of some varieties lack vigor and are slow to initiate runners. Consequently, a poor stand of plants may be obtained and yields are sometimes low when such stocks are grown. Catskill is a good example of this. When the plants are virus-free, they are very vigorous and run freely early in the season. Properly spaced plants of this sort will generally give much higher yields than plants from unselected stocks if cultural and environmental conditions are favorable for good growth and fruit production throughout the season.

Catskill is known to be sensitive to virus, and following infection it quickly degenerates. Isolation from common stocks and aphid control is necessary in the maintenance of substantially virus-free plants. When common stock is grown adjacent to virus-free stock, some re-infection occurs even with frequent dusting with an insecticide to control aphids.

Robinson is one of the more tolerant varieties with respect to virus in Michigan. In the experiments conducted here, no differences of practical significance in runner production or vigor could be detected when virus-free plants were compared with common stocks.

The virus-free strain of Premier was more prolific in total runner production than the standard Michigan strain, but it was pointed out that the virus-free strain produced many relatively unfruitful plants late in the season. Also, the berries of the latter were very light in color, and in tests here, gave a poor frozen product. It is doubtful if it should replace the local common stock, particularly since Premier is tolerant to virus in Michigan. Virus-free plants of the local strain of Premier have not yet been obtained.

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THE MICHIGAN VIRUS FREE STRAWBERRY CERTIFICATION PROGRAM[1]

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THE WEAKENING of strains in varieties of strawberries accompanied by reduced yields and runner production have been reported through the past years in Michigan. Many reasons, mostly unsatisfactory, have been proposed for this varietal "running out".

The possibility that these disorders were of a virus nature was considered. Determination of virus contamination was always considered a lengthy and difficult task, but in recent years, development of facilities and methods has made this determination feasible.

The importance of this problem was not realized until 1949 when viruses were isolated by the United States Department of Agriculture from strawberry plants propagated in Michigan. Furthermore, importation of the Marshall strawberry from the Pacific Northwest implicated a virus disease unknown to Michigan. These findings were met with concern because Michigan is considered a leading state in strawberry plant and fruit production.

In 1950 a research program was initiated by the Michigan Agricultural Experiment Station to establish strawberry virus research which would ultimately serve the strawberry industry of Michigan. One of the first objectives was to establish a foundation stock of virus-free strawberry varieties. These would be made available to cooperating nurseries for future grower use and for further development of a certification program for the propagation of such stock.

DEVELOPMENT OF VIRUS-FREE STRAWBERRY PLANTS

Generally speaking, most virus diseases present in Michigan strawberry plants display no visible diagnostic symptoms. Therefore, in

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order to determine if a virus is present in a given plant, it must first be tested or "indexed". This procedure entails grafting a runner of the test plant to a runner of an indicator plant that is extremely virus sensitive.

If the test plant is contaminated with virus, the grafted indicator plant will show definite symptoms within a few weeks and the test plant is discarded (Fig. 1). If no reactions are evident within this

Fig. 1. 9—"Indexed" test plants lined out in sandbench for virus determinations. 10—Blakemore, symptomless carrier of virus (left); Expression of virus on indicator plant (right). 11—Yellows virus on indicator (left); Dunlap, symptomless carrier of virus (right). 12—Yellows virus symptoms of curling on stems and leaves of virus sensitive indicator plant.

period, the test plant is "indexed" again to several more indicator plants to verify or refute the original finding. Meanwhile the runner plants developed from this apparently virus-free test plant are rooted in sterilized soil to prevent any possible contamination by nematodes or root rotting diseases.

The next step is to move these rooted virus-free plants to a screenhouse or "strawberry bank" for further propagation and isolation (Fig. 2). This screenhouse, covered with a fine plastic screen, protects the "indexed" virus-free strawberry plants from aphids that spread

Fig. 2. Screenhouse or "strawberry bank" used for the isolation and propagation of the virus-free foundation stock.

viruses. As a further precaution the soil in the screenhouse is fumigated prior to planting with Dowfume MC-2[3] to control weeds, soil insects, or nematodes that might be present.

Fig. 3. Inside view of screenhouse, partitioned sections contain virus-free plants of the individual varieties.

[3]A proprietary methyl bromide formulation of the Dow Chemical Co.

Within a 3-year period, 575 plants were received for testing from growers and nurseries throughout Michigan. This extensive search resulted in the isolation of seven virus-free varieties. Additional varieties, free of virus were obtained from other state and federal cooperative programs. At the present time 31 varieties are deposited in the Michigan "strawberry bank" (Fig. 3). Now, large quantities of Catskill, Marshall, and Robinson varieties, comprising 60 percent of the total Michigan strawberry acreage, are available to growers through the several cooperating Michigan nurseries.

PROPAGATING VIRUS-FREE PLANTS

Foundation Stock

1. Three-fourths of the plants of a given variety are removed from the screenhouse in the spring and lined out in an isolated field about 1 mile from either commercial or wild strawberries.
2. The planting site has not had a previous history of the Red Stele root rot disease nor been cropped to potato, tomato, or eggplant within the last 5 years. The latter measure was to alleviate the possibility of the fungus disease, Verticillium wilt. Also the soil is fumigated prior to planting for nematode control.
3. Border rows of the indicator plant encompass the field to serve as a check for possible virus contamination.
4. The field is dusted at 10-day intervals from the time of planting until fall frost with a 1 percent parathion dust to further protect the foundation stock against virus infection by aphids. The following spring substantial quantities of these plants are made available to cooperating Michigan nurseries.

Cooperating Nurseries

State certified, substantially virus-free strawberry plants are propagated by several Michigan nurseries that meet the rigid requirements for production of such stock.

1. The cooperator must first have his proposed planting site surveyed by an inspector from the Michigan Department of Agriculture in order to ascertain if the boundaries of the field are isolated 1,500 feet from either commercial or wild strawberries.
2. The soil in this area must not have been exposed to Red Stele root rot at any time. This precaution is taken because studies

indicate that the Red Stele fungal organism can survive in certain heavy soils for 12 years, even when crops other than strawberry have been grown there. Furthermore the planting site should not have been cropped to potato, tomato, or eggplant within the last 5 years.

3. The accepted field site must be fumigated with a soil fumigant for nematode control. Preferably, the fumigation should be accomplished the fall prior to planting.
4. The cooperator must dust all strawberry plants and their progeny at 10-day intervals during the growing season with 1 percent parathion at the rate of 20 pounds per acre. Spraying may be substituted for dusting if a solution containing ¾ pound of 15 percent wettable parathion per 100 gallons is applied at the rate of 150 gallons per acre.
5. The cooperating nursery must return to the Michigan Agricultural Experiment Station Foundation Stock source for plants at least once every 4 years, although the cooperator may receive stock from this source every year. Strawberry plants, more than 5 years removed from the foundation stock, will not be considered for certification under this program.
6. Frequent inspections of the plantings are made by Plant Industry Division field representatives during each growing season. Two of these inspections, one in late spring for root rots, June yellows, and insects; and a second during early fall for root-knot nematode, insects, and root rot are the minimum required by law for the certification of strawberry plants. Other inspections are made to check for virus contamination and to determine that a thorough and effective spray schedule is being followed for the control of aphids and such foliar diseases as leaf blight and spot.
7. The foregoing requirements are the subject of a signed agreement between the cooperator, the Michigan Agricultural Experiment Station and the Michigan Department of Agriculture. The merits of the planting stock produced are given recognition by the issuance of a special certificate entitling the cooperator to advertise and sell substantially virus-free plants.

RESEARCH

Every season, plants from the screenhouse and the foundation stock field are re-tested for virus contamination. To date none has

been found. Strains of the Premier variety are being screened continually in an attempt to isolate a virus-free plant of the old standard Kellogg Premier.

In addition, virus-free clones of promising selections from the station's strawberry breeding program are being isolated, so that virus-free stock will be available in the event that one or several of them become named varieties. Studies on virus inactivation within the plant, seasonal spread of the virus, and reinfection of virus-free stock in commercial plantings are under way.

It is assumed that findings from this research will not only aid in modifying the present certification program but will ultimately contribute significantly to Michigan's strawberry industry.

Virus-free foundation stock of many commercial varieties has been developed and subsequent increase of some has been made available to the cooperators. A large supply of foundation plants of the major varieties grown in Michigan is a goal nearly reached. Thus, the fruit growing industry can look forward to an ever increasing supply of better producing strawberry plants.

STUDIES ON STRAWBERRY LEAF SPOT IN MICHIGAN

PROGRESS REPORT

By ROBERT H. FULTON
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STRAWBERRY LEAF SPOT, *Mycosphaerella fragariae*, in Michigan plantings has been sporadic through the years. However, epidemics of this disease may occur, as in 1957. Such occurrences of leaf spot can kill entire leaves resulting in reduced yields, lower grade of harvested berries, and a loss in vigor of affected plants.

During 1957, several recognized facts were observed about this disease. Many Michigan growers are not familiar with the disease since most of the old major varieties are resistant, while several of the new varieties and selections were evaluated as susceptible. The role weather plays is important. Furthermore, sprays of fixed copper were not arresting the disease in experimental plots.

A description of the disease and a report of the several observations connected with the preliminary studies seems warranted.

THE DISEASE

This fungus disease is first noticeable in the spring as small, purplish, circular spots on the upper surface of young leaflets (Trelease, 1885). As the fungal infection continues, the center of the spot becomes gray to white in color, is surrounded by a broad reddish-purple margin, and is generally ⅛ to ¼-inch in diameter (Fig. 1). Leaf spot infections on the under surface of the leaflets are similar in appearance to those on the upper surfaces, though less brilliant in color.

In addition, if the main or any lateral leaflets' veins come in contact with a spot, they develop a premature reddish-purple color

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Fig. 1. Strawberry leaf spot, note characteristic white centers and dark margins of spots.

that generally extends beyond the infected areas. The leaf spot fungus may also attack leaf stems, fruit stalks, and fruit calyxes exhibiting infected spots similar to those described for the leaves. On the stems and stalks, however, the lesions tend to be more elongated than circular.

Infection of strawberry fruit by this fungus is not too common. When it does occur it is quite conspicuous on white unripe fruits or on ripe fruits of light-colored varieties. On the fruit the disease has been called "black seed" (Demaree and Wilcox, 1938). Usually one to several seeds on the berry, including the area surrounding them, are brownish-black in color (Fig. 2). The pulp of the berry under these infected areas is discolored. Although there is no rotting of the fruit, these lesions have such a distracting appearance that they lower the grade or render the fruit unmarketable.

VARIETAL RESISTANCE

The resistance and susceptibility of strawberry varieties has been noted over the years. Thus, Premier is well known as a resistant variety. However, many new varieties and selections have been recently introduced from the Michigan breeding project and from other state and federal programs.

Fig. 2. Black seed disease of strawberry fruit. Note darkened seeds and their surrounding area. Photo courtesy of U.S.D.A.

An opportunity to evaluate many of these new varieties under Michigan conditions was presented in 1957 at the C. O. Zollar Strawberry Nursery, Benton Harbor, Michigan. A 1-year-old field of 29 varieties and 15 selections was available for study. Three separate evaluations were made in this planting in 1957; the ratings are presented in Table 1.

From this study it was apparent that Catskill, Premier, and Robinson are but little affected by this disease. As these varieties constitute the major portion of the Michigan strawberry acreage, the reason for little trouble with leaf spot in the past years is evident.

However, several new red stele resistant varieties are being widely planted such as Fairland, Paymaster, Redglow, and Sparkle. These were evaluated as very susceptible; the leaf spot was severe. It is

TABLE 1—Resistance of strawberry varieties and selections to leaf spot, Benton Harbor, Michigan, 1957

Ratings (*a*)			
Healthy	Slight	Moderate	Severe
Belmar	Earlidawn	Aroma	Armore
Catskill	Empire	Blakemore	Erie
Fairfax	Robinson	Dunlap	Fairland
Klondike	Surecrop	Jerseybelle	Marshall
Premier H-17	Thomas	Pocahontas	Paymaster
Premier USDA	Wisc. 214	Red Crop	Plentiful
Tennessee Beauty	M 63	Temple	Redglow
Shasta	M 383	Vermillion	Sparkle
M 3 (*b*)		M 38	M 10
M 262		M 44	M 26
M 295		M 1065	M 320
M 1003		M 1095	
M 1156			
M 1195			

(a) Average of three evaluations, healthy—no infection; slight—one to two spots per leaflet; moderate—three to five spots per leaflet; severe—more than five spots per leaflet.
(*b*) M numbers from Michigan breeding project.

apparent from this that control of leaf spot by fungicides may need more attention in Michigan.

ROLE OF WEATHER

The leaf spot fungus overwinters in previously infected leaflets and in other plant parts. In the spring, clusters of spores emerge from these infected spots during periods of high relative humidity. These are scattered by rains to developing young leaves which are extremely susceptible (Fig. 3). Therefore, leaf spot in a given strawberry planting is favored by low spring temperatures and prolonged wet periods. . . protracted cold weather delays the maturity of the young leaves and the prolonged wet periods are conducive to spore production, dissemination, and infection.

The weather data in the Benton Harbor strawberry area compiled for the spring growing period of the last 2 years may indicate why leaf spot was so severe in 1957. This climatological data is presented in Table 2.

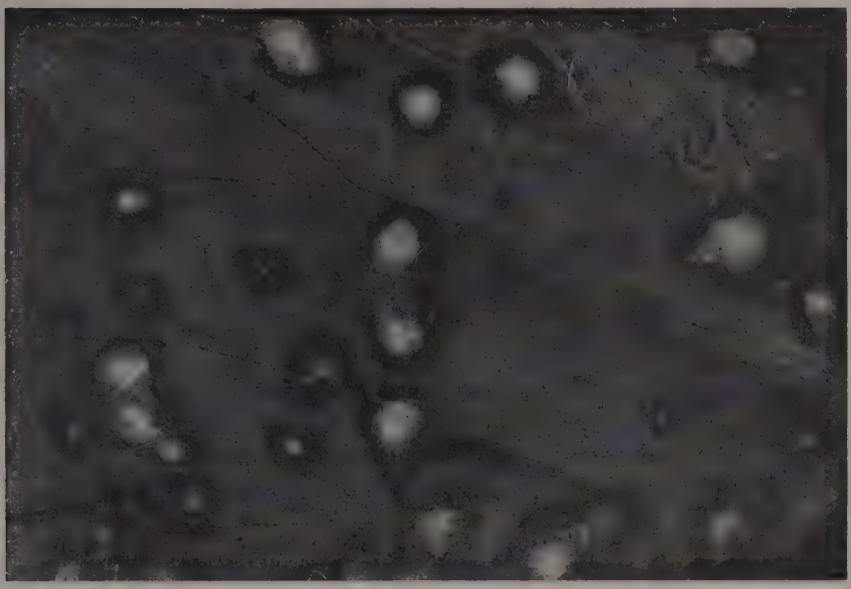

Fig. 3. White tufts of spores in the leaf spot lesions following a rain period.

As indicated in Table 2, the average temperature for the 2-month spring period covering 1956 and 1957 was only slightly lower in 1957 than in 1956. This lower temperature is more important in holding back plant growth than it is in the development of the fungus.

The optimum temperature range for spore production and germination of the fungus is between 55° and 70° F. (Fall, 1951; Plakidas,

TABLE 2—Climatological data for April and May during 1956 and 1957 on average temperature and precipitation in the Benton Harbor area (a)

Month	Year					
	1956			1957		
	Av. temp. F°	Precipitation		Av. temp. F°	Precipitation	
		Days no.	Total inches		Days no.	Total inches
April	46.2	12	5.04	48.0	21	5.70
May	59.0	13	3.30	57.0	12	4.58

(a) Compiled from Climatological Data, Michigan monthly report, U. S. Dept. Commerce, Weather Bureau.

1931). However, a lower temperature definitely delays the maturity of the young leaflets, thus extending their susceptible period.

The data presented on rainfall are more important than those of temperature. In April of 1957, there were 21 days of rainfall; there were 12 in 1956. In May, rainfall for 1956 and 1957 were comparable. Thus, the rainfall of April, 1956, and a proportionately high number of days of rain in May were responsible for a build up of leaf spot inoculum in many of the newly set strawberry fields. In April and May of 1957 an even higher number of days of rain was recorded. This initiated the overwintered inoculum for the severe primary and secondary infections of leaf spot in these 1-year-old matted row fields. The result was an epidemic outbreak of leaf spot.

These findings on climatological data in Michigan substantiate those reported by Dale and Fulton (1957). They also found that abnormal spring rainfall was conducive to severe leaf spot infections.

EFFECT OF FUNGICIDES

In 1931, Plakidas showed that an 8-8-100 Bordeaux mixture applied every 10 days during the growth period gave almost complete control of the disease. It also increased yields about 49 percent.

Further studies (Plakidas, 1938) indicated that Bordeaux does not effect the fungal mycelium within the leaf tissue but does inhibit sporulation, especially on the upper leaf surface. This greatly reduces the amount of potential infective inoculum.

Continued investigations by Plakidas (1942, 1943) showed that Tri-Basic copper sulfate[1], used at a rate of 4 pounds per 100 gallons was equivalent to 8-8-100 Bordeaux for strawberry leaf spot control. His studies on spore germination revealed that the leaf spot fungus was extremely sensitive to copper. A further dilution of Bordeaux showed that a 4-4-100 concentration was very effective and could be recommended.

A recent study (Sharvelle and Teller, 1950), on the evaluation of several copper fungicides showed Yellow Cuprocide to be the most effective in control but also the most injurious to strawberry leaves. The other materials, Bordeaux, Microgel, and Tennessee Copper 34, were less effective and plant injury by Bordeaux was almost comparable to that of Yellow Cuprocide. They concluded that none of the materials tested could be substituted for Tri-Basic copper sulfate as a control for strawberry leaf spot.

[1]Fifty-three percent neutral fixed copper, a proprietary formulation of the Tennessee Corporation.

In the spring of 1957, a 1-year-old field of the Sparkle variety was found severely infected with leaf spot. Since no fungicides had been applied to this planting, it was desired to determine if sprays of Tri-Basic fixed copper would check the disease. It also afforded an opportunity to evaluate a new experimental fungicide, Cyprex[2], which was outstanding against cherry leaf spot (Cation, 1957).

The plots received three applications: (1) Full bloom, (2) berries one-third grown, (3) 10 days before harvest. Post harvest counts were made on the new growth developed following the first application and are presented in Table 3.

TABLE 3—A comparison of Cyprex and Tri-Basic copper for the control of strawberry leaf spot on the Sparkle variety in 1957

Materials	Dosage per 100 gal.	Spots per 25 leaf sample (*a*)				Totals		Infection av. percent
		Sample I no.	Sample II no.	Sample III no.	Sample IV no.	Spots no.	Av. per leaf	
Cyprex...	2 lb.....	24	17	14	16	71	0.71	4.35
Tri-Basic Copper.	2 lb. (*b*)..	131	218	245	167	761	7.61	46.60
Check....	.....	390	419	441	383	1,633	16.33	100.00

LSD at .05..... 48.41
LSD at .01..... 73.31
(*a*) Representative sample from each one rod replicate.
(*b*) Dosage rate equivalent to a 4-4-100 Bordeaux mixture.

As indicated in Table 3, Cyprex was outstanding. Almost complete control of leaf spot was obtained with no apparent injury. The Tri-Basic copper applications reduced infections to only 46 percent. Also, some injury, consisting of a reddening of the leaflet margins and the caps of the berries, was observed.

During the period of this test, weather conditions were ideal for continued secondary infections (Table 2). Therefore, the results presented here are indicative of Cyprex as a potential fungicide for the control of strawberry leaf spot.

SUMMARY

The symptoms of strawberry leaf spot are presented as they appear on the leaflets, stems, and on the fruit. Observations on varietal

[2]n-Dodecylguanidine acetate, a proprietary formulation of the American Cyanamid Company.

resistance reveal that most of the major varieties in Michigan are resistant. Several of the recently introduced red stele resistant varieties, Fairland, Paymaster, Redglow, and Sparkle, were quite susceptible.

A comparison of temperature and rainfall for the Benton Harbor area indicated favorable conditions for an epidemic. The low temperatures delayed maturity of the plant parts, thus lengthening the infection period. Meanwhile excessive rain periods were favorable for fungus development and distribution of spores.

A new fungicide, Cyprex, gave exceptional control while Tri-Basic copper was only partially effective and resulted in some injury.

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THE INFLUENCE OF CERTAIN PACKAGING MATERIALS AND PROCESSING TAGS ON THE CONSUMER PREFERENCE OF CHICKEN FRYERS

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A LARGE PERCENTAGE of fryers are being merchandised unpackaged in ice, but the practice of selling individually packaged birds is increasing.

Transparent covering materials are being used to protect the birds from contamination. Frequently, absorbent trays are utilized to make the package more acceptable to the purchaser. Little is known about consumer preference for a specific color of packaging materials available or for a particular type and transparency of overwrap.

Besides quality of the unpackaged product, the displayed appearance may modify the purchasers' evaluation of a particular fryer, thereby affecting consumer selection when they actually make purchases. In this article, tests of the influences of the type of protective overwrap, the color of the package, and the type of inspection and processing tag are reported.

GENERAL PROCEDURE

These fryer tests were part of a consumer evaluation of quality factors found in several agricultural products: apples, potatoes, pork chops, eggs, poultry, and roses.

These evaluations were made by about 130 Detroit consumers at the Home Economics Laboratory of Wayne State University. A majority of these panel members were between 30 and 45 years of age, were high school graduates, and had family incomes ranging

[1]The authors wish to express appreciation to Mrs. M. J. Bostick, Mrs. D. Place and Mrs. F. G. Sanderson of Wayne State University, for their help in planning the panel meetings.

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from $4,000 to $10,000.[2] Comparable panels had met 13 times since January 1956. The tests reported here took place in December 1956, and January and April of 1957.

Type of fryer package overwrap

Five chicken fryers of apparent equal quality were packaged in the laboratory of the M.S.U. Poultry Department. Each fryer was placed in an absorbant tray within the various overwraps shown in Fig. 1. Describing the overwraps briefly: the cellophane was colorless and bright lights caused it to glare making the product difficult to see at certain angles. The polyethylene was dull and was slightly milky in color. The print overwraps were similar to the above except that

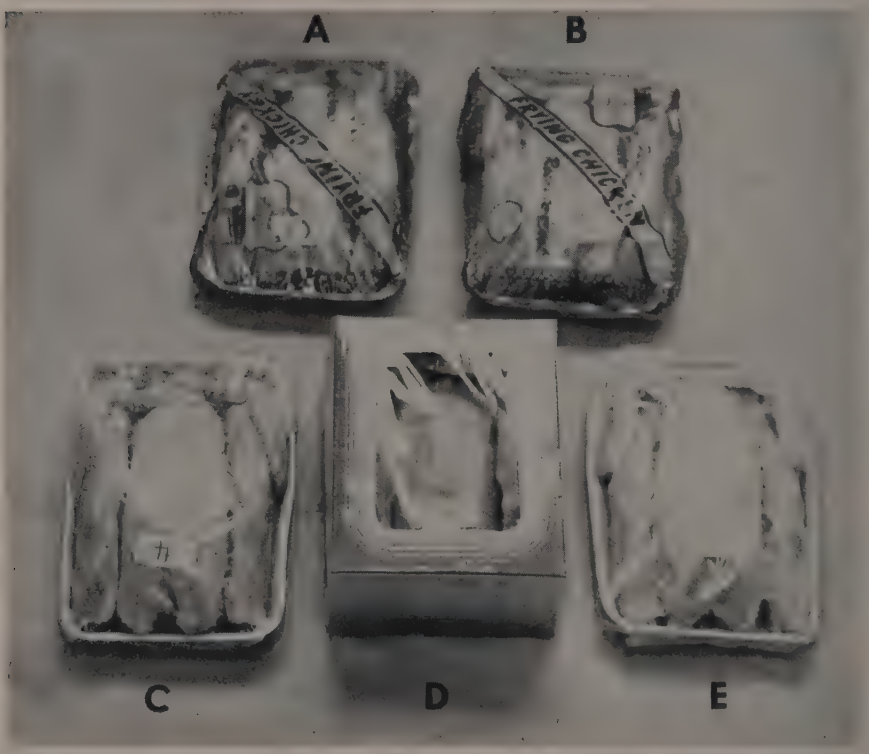

Fig. 1. The packaged fryers exhibited in Test 1; (a) cellophane—color printed, (b) polyethylene—color printed, (c) cellophane—plain, (d) light blue box with cellophane window, (e) polyethylene—plain.

[2]For further details regarding the selection of panel members, see: Larzelere, H. E. and R. D. Gibb (1956). Consumers opinions of quality in pork chops. Michigan Agr. Expt. Sta. Quart. Bul. 39: 327-333.

some decoration of red coloring and printing was added. The fifth package had a light blue box with a cellophane window on top.

Following packaging, the fryers were frozen for holding purposes but were thawed completely and placed on iced trays for display to the panel members. The same general procedure was used in preparing the samples in each of the tests reported here.

The panel members were not told of the different kinds of material used as overwraps but were asked to rank the five fryer packages in the order which they would select them if the price were the same. Some of the differences between the samples in Table 1 can be attributed to slight differences in the fryers themselves.

TABLE 1—Preference for type of overwrap for packaged fryers—April 1957

Description of sample	Percent of panel ranking sample as first choice
Polythylene—plain	43
Window package	24
Polyethylene—print	14
Cellophane—plain	14
Cellophane—print	5
Total	100

In the case of the two pairs of samples, namely the plain and print polyethylene; and the plain and print cellophane, the plain samples of each material were ranked above the corresponding print sample. A plain overwrap may have been preferred because it permitted a closer examination of the fryer than was possible with the red coloring and printing. Comparisons with other colors and printing, of course, might not have given comparable results.

Inspection and Processing Tags

In this test the same series of fryers was displayed in January as in December. In tests 2 and 3 the samples were refrozen for holding from one month to the next. To the trained eye there was no appreciable change in the relative quality of the five samples. The tags attached to the fryers, however, were switched so that each sample in January had a different tag than in the previous December. A given symbol identified the same bird at both meetings (Table 2).

TABLE 2—Consumer selection of fryers with various inspection and processing tags—December 1956 and January 1957

Tag in December	Tag in January	Percent of panel selecting sample as 1st choice in December	Percent of panel selecting sample as 1st choice in January
U. S. Inspected (*a*).....	Michigan Inspected.....	35	34
Acronized.....	U. S. Inspected and graded "A".....	24	27
U. S. Inspected and graded "A".....	No tag.....	20	23
No tag.....	Acronized.....	13	13
Michigan Inspected (*b*)..	U. S. Inspected.....	8	3
	Total.....	100	100

(*a*) Complete designation is "Inspected for Wholesomeness by the U. S. Dept. of Agr."
(*b*) Complete designation is "Inspected and Passed by the Mich. Dept. of Agr."

As indicated in Table 2, the number of panel members ranking the different birds as first choice was very similar at the two meetings. The tags attached apparently had little to do with the selections. For example, the bird with a U. S. Inspected tag had the largest number of first choices in December, whereas in January the bird with that tag had the fewest number of first choices. Similar observations can be made regarding the other samples and tags.

Color of Package

In this series of tests the birds were placed in wicker type baskets with pulp board inserted as a bottom and wrapped in cellophane. In the December meeting the baskets were all yellow. For the January meeting the birds were repackaged in baskets of five different colors (Table 3). A given symbol identified the same bird at both meetings. As in Test 2, to the trained eye, there was no appreciable change in the relative quality of the five birds.

Table 3 indicates that the bird in the blue basket in January had a substantial increase in percentages of first choices in January over December. The birds in the yellow and white baskets had fewer first choices. Only small changes were noted in the change from yellow

TABLE 3—Consumer selection of fryers in same and various colors of tray-baskets—December 1956 and January 1957

Color in December	Color in January	Percent of panel selecting sample as 1st choice in December	Percent of panel selecting sample as 1st choice in January
Yellow	Yellow	44	34
Yellow	White	37	21
Yellow	Blue	7	29
Yellow	Red	7	10
Yellow	Green	5	7

to the red or green baskets. Some color preference apparently existed but it was minor as compared with the visual quality of the bird.

In the April meeting, for example, a different group of fryers was packaged in the five different colored baskets (Table 4). The bird in the green basket was ranked as first choice by a large percentage of the panel but this was probably due to its superior quality in the eyes of the panel members.

TABLE 4—Consumer selection of fryers in tray-baskets of various colors—April 1957

Color	Percent of panel selecting sample as 1st choice
Green	46
Blue	20
Red	14
White	12
Yellow	8

An additional limitation of a color comparison is that the results apply only to the particular shades of color in which the baskets were available. Other shades might change the effects of the color differences.

SUMMARY

These tests indicate the need for more comparisons of consumer preferences for different wrapping materials, different inspection tags, and different colored packages. The tests should also take into ac-

count differences in the quality of the unwrapped poultry whether in preference panels or in store merchandising tests. Several significant findings, however, can be observed:

1. With acknowledgment of the effect of possible differences in the fryers themselves, there was some evidence that many panel members preferred the plain wrappers which permitted closer observation of the bird itself over the red colored and printed wrappers that were tested.
2. Most panel members selected the chicken fryers on the basis of the quality of the bird itself rather than preferring a particular inspection, grade, or processing tag.
3. The appearance of the fryers themselves seemed to be of greatest importance to the panel members. However, some increase was noted in numbers of first choices for the bird shifted from a yellow to a blue tray basket. A decrease in the number of first choices was noted for the bird remaining in a yellow tray basket in both tests or for the sample that was shifted from a yellow to a white tray basket.

AN EVALUATION OF SYSTEMIC INSECTICIDES FOR CONTROL OF HESSIAN FLY IN MICHIGAN

By GORDON E. GUYER, HUBERT M. BROWN and ARTHUR WELLS

Departments of Entomology and Farm Crops

There is a constant desire on the part of farmers to plant winter wheat early in the late summer planting period to insure better establishment of the stand, and in some cases, to utilize the wheat for pasture.

As early as 1910, Pettit (1910) wrote, "probably the worst enemy of wheat in Michigan is the 'fly' or Hessian fly." Generally, the control of the Hessian fly, *Phytophaga destructor* (Say), has consisted of delaying the planting date of wheat until the cooler weather of September has limited egg laying activities (Pettit, 1922).

The first report that systemic phosphate insecticides might be effective for control of Hessian fly was published by Brown (1957).

This investigation was aimed at the utilization of systemic insecticides for control of this pest under Michigan conditions.

PROCEDURE

The locations, varieties used, dates of planting, and dates of digging plants are given in Table 1.

The initial experiment was established in September of 1956 and included a control and three Thimet seed treatments at the rates of 0.5, 1, and 2 pounds of actual toxicant per acre applied as a 44 percent carbon formulation. Two fly-susceptible wheat varieties, Kharof and Vigo, were used.

As a result of the apparent success in the fall of 1956 in controlling the fly, an enlarged study was planned for the spring of 1957. Experiment II was conducted at East Lansing using Henry spring wheat. In addition to Thimet, Bayer 19639 (Di-syston) was included in the

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TABLE 1—Planting and harvesting information for the 1956 and 1957 experiments

Experiment number	Location	Variety	Date planted	Date dug
I	Farm Crops farm, East Lansing.....	Kharkof, Vigo	Sept. 12, 1956	Nov. 23, 1956
II	Farm Crops farm, East Lansing.....	Henry.....	April 19, 1957	July 17, 1957
III	Farm Crops farm, East Lansing.....	Kharkof, Dual	Aug. 27, 1957.	Nov. 4, 1957
IV	Hartsell farm, (a) Cass County.....	Kharkof, Dual	Aug. 28, 1957.	Oct. 29, 1957
V	Richter farm, (a) Cass County.....	Kharkof, Dual	Aug. 28, 1957.	Oct. 29, 1957
VI	Meyers farm, (b) Lapeer County	Genesee.....	Aug. 21, Sept. 3 and 17, 1957....	Oct. 18, 1957

(a) In cooperation with Mr. Harold Sparks, County Agricultural Agent, Cass County.
(b) In cooperation with Mr. William Van Scoik, American Cyanamid Company, Ft. Wayne, Ind.

experiment. Seed treatments and in-row applications of granulated formulations were evaluated.

Experiments III, IV, and V consisted of the same two toxicants, at different locations with the addition of a fungicide in two of the treatments. In experiments III, IV, and V, Kharkof was used for the treatments and also as the susceptible control, while Dual was used as the resistant control variety.

The seed treatments for experiments I to V were made with 1 pound of the seed to be treated being placed in a gallon jar and dampened slightly. The carbon formulation of the insecticide was added to the seed. The jar was rotated until all of the material adhered to the seed. When a fungicide was included in the treatment, the fungicide was applied directly to the seed, followed by the insecticide. In some treatments it was necessary to include small quantities of Methocel to insure the adherence of the seed treatment. All seed treatments were made within 1 week of the planting date.

In experiment I, the treatments were arranged in a randomized block design with four replications. In experiments II, III, IV and V, the same randomized block procedure was followed but with eight

replications. Experiments I to V were hand planted with the rows 10 feet long and 1 foot apart. Genesee seed was used in experiment VI. It was treated with a commercial seed treating machine and planted with a 13-row drill as single drill-width plots running across an 80-rod field.

The wheat used in the experiment was planted at 100 pounds per acre, near wheat fields harvested the season before the test plantings were made. Infested stubble was distributed in alley-ways of experiment III to increase the possibility of infestation. All rates of in-row applications were based on 87,120 linear feet of row per acre.

Plants from a 3-foot section of row (experiments I to V) were dug and placed in a labeled paper bag. In experiment VI, three samples per plot were taken, one by each of three observers. Each sample consisted of plants randomly pulled at rod intervals as the observers walked the full length of the plot.

All samples were stored in a refrigerated room at a temperature of 50° F. Each sample was carefully examined and the data recorded as in Tables 2 through 5. In all cases referring to percent infestation or insects per 100 plants, the total population of larvae and pupae on the plants is included. Pupation was 90 percent, or more, completed at harvest time in all of the plots.

A study was initiated in cooperation with the American Cyanamid Company to ascertain the rate of translocation and dissipation of Thimet in the plants. Samples for residue analysis were taken at 7 to 15-day intervals from the Lapeer County plots sown August 21. The plots were sampled six times between September 3, 13 days after planting, and October 25 (Fig. 1). Composite samples were taken from the entire length of the 80-rod strip and only the above-ground portion of the plants was sampled for analysis. The samples were quick frozen and held at 0° F. until they could be analyzed by the American Cyanamid Company.

PRESENTATION AND DISCUSSION OF RESULTS

Results from the preliminary study in the fall of 1956 (experiment I) indicated that systemic insecticides might provide control of Hessian fly on wheat. The low infestation of 5 percent in the control led to caution in the interpretation of the results. It was postulated that the late planting date (September 12, which was only 5 days prior to the fly-free date) was responsible for this low infestation. However, the

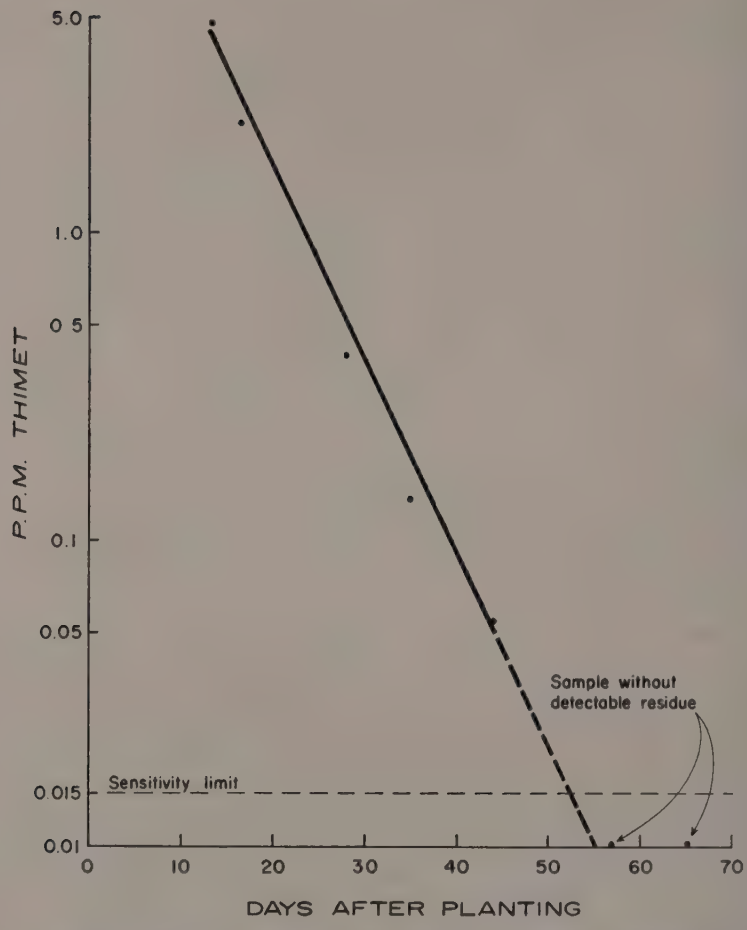

Fig. 1. Rate of Thimet disappearance in wheat calculated as p.p.m. 3919 Sulfone.

absence of pupae in the plants from the plots planted with treated seed indicated that further studies would be in order.

The results of the 1957 experiment conducted with spring wheat are presented in Table 2. There was a significant reduction in the stand as a result of the seed treatment with 1 pound of Thimet. The plants in both of the seed treatments with Thimet were slow in emergence and stunted for several weeks. There was an indication that the infestation, both as percent of plants infested and as insects per 100 plants. was reduced by the seed treatments with ½ and 1 pound of Thimet.

TABLE 2—Plants per foot, percent of plants infested and number of insects per 100 plants from experiment II, East Lansing, summer, 1957

Material	Pounds of actual insecticide per acre	Plants per foot	Percent of plants infested	Number of insects per 100 plants
Thimet, 44 percent carbon	½	10.0	9.4	15.1
Thimet, 44 percent carbon	1	6.6	8.7	10.1
Thimet, 2 percent granulated	1	15.6	15.9	23.7
Bayer 19639, 50 percent carbon	½	12.0	17.9	24.6
Bayer 19639, 50 percent carbon	1	13.4	17.2	21.6
Bayer 19639, 2.5 percent granulated	1	16.7	13.1	18.1
Control		14.2	18.4	27.1
R.E. (*a*) at 5 percent level		4.3	NS	NS
R.E. (*a*) at 1 percent level		5.7		

(*a*) Range of equality based on Duncan's (1955) significant studentized ranges using only the maximum number of means in each table, hence giving the maximum range needed for significance. Any differences or sums of consecutive difference less than the R. E. values are, for sake of simplicity, not considered significant or equal.

Due to the variability in these data, these differences did not prove significant at the 5 percent level. Perhaps the reason for the poor control in this spring study was the extended period between planting and the first observation of larvae on the plants; 5 weeks elapsed between planting and the time the first larval activity was observed.

Although the results from the spring study were not extremely encouraging, they did present sufficient positive data to warrant continuing the study during the fall of 1957.

In plots planted in the fall of 1957 (experiments III to V), there was a significant reduction in the infestation in all of the treatments over the control. This difference was evident both in the percent of infested plants and in the insects per 100 plants (Table 3). The range in number of specimens on infested plants varied from 1 to 12. It was surprising to observe the relatively high mean infestation in the control plots of the Dual variety for experiment IV.

The reason for the heavy population of insects in Dual plants at the Hartsell location was not clear. It might be due to differences in race variability relationships as indicated by Painter (1930) and summarized by Gallun (1955), but experiment V was located only 1 mile from the Hartsell plots and had a relatively light infestation in the Dual control in comparison to the Kharkof control. However, it seems doubtful that a real difference in races would exist in such

TABLE 3—Percent of infested plants and number of insects per 100 plants, experiments III, IV and V, at East Lansing and in Cass County, fall, 1957

Material	Pounds of actual insecticide per acre	Percent of infested plants				Number of insects per 100 plants			
		Experiment			Mean	Experiment			Mean
		III	IV	V		III	IV	V	
Thimet, 44 percent carbon.....	½	0.5	3.0	1.5	1.7	0.5	3.7	1.9	2.0
Thimet, 44 percent carbon.....	1	0.0	2.4	0.6	1.0	0.0	2.4	0.9	1.1
Thimet, 44 percent carbon Arasan 75 (*a*).....	1	0.0	0.4	1.9	0.8	0.0	0.4	2.6	1.0
Thimet, 2 percent granulated ..	1	1.0	3.8	1.6	2.1	1.0	4.2	1.9	2.4
Bayer 19639, 50 percent carbon.	½	0.9	4.2	5.0	3.4	1.2	5.2	6.0	4.1
Bayer 19639, 50 percent carbon.	1	0.5	3.4	2.4	2.1	0.5	4.6	2.4	2.5
Bayer 19639, 50 percent carbon Arasan 75 (*a*).....	1	2.1	4.6	2.1	2.9	2.1	5.5	3.0	3.5
Bayer 19639, 2.5 percent granulated.....	1	2.1	8.0	4.1	4.7	3.7	9.9	4.1	5.9
Control (Kharkof).....		14.8	26.8	13.2	18.3	22.4	46.0	18.2	28.9
Control (Dual).....		1.4	29.8	4.2	11.8	1.9	43.2	5.9	17.0
R E. at 5 percent level.....					9.6				15.2
R.E. at 1 percent level.....					13.3				20.9

(*a*) Arasan 75 applied at rate of 4 oz. per 100 pounds of seed.

close proximity. Generally, the infestations in the treatments with Thimet were consistently less than in comparable plots treated with Bayer 19639, although the differences were not significant.

In experiments III, IV and V, there was a significant reduction in stand (Table 4) with the seed treatment of 1 pound Thimet without the Arasan. Weekly observations indicated, in addition to the reduction in stand, the heavier seed treatments retarded growth. With the passage of time, however, the plants from treated seed caught up with and surpassed those in the control plots planted with Kharkof. This is shown (Table 4) by the heavier weights per plant.

The data in Table 4 indicate that a significant increase in weight per plant occurred when Thimet was used in comparison to the controls sown to Kharkof. A similar, though lesser, increase in weight was evident in the plants receiving Bayer 19639 treatments. There appeared to be some factor, other than the direct control of the insect, and plant competition that contributed to this increase in weight. Brown (1957) reported a similar increase in plant growth with certain fertilizer-systemic insecticide mixtures.

The results of experiment VI are presented in Table 5. Excellent control of the larvae, when present, was evident. The infestation continually declined, as the season progressed, with no specimens present in the plants sown September 17. This seeding was made 2 days after the fly-free date for the Lapeer area.

TABLE 4—Number of plants per foot and weight per plant in grams, experiments III, IV and V, at East Lansing and in Cass County, fall, 1957

Material	Pounds of actual insecticide per acre	Number of plants per foot				Weight per plant in grams			
		Experiment			Mean	Experiment			Mean
		III	IV	V		III	IV	V	
Thimet, 44 percent carbon.....	½	14.5	13.9	14.9	14.4	12.7	3.9	5.9	7.5
Thimet, 44 percent carbon.....	1	13.4	11.1	13.9	12.8	13.1	4.7	7.0	8.3
Thimet, 44 percent carbon Arasan 75 (*a*).....	1	20.9	16.5	18.0	18.5	10.1	5.1	5.7	7.0
Thimet, 2 percent granulated ..	1	17.7	16.6	20.5	18.3	11.7	4.2	5.4	7.1
Bayer 19639, 50 percent carbon.		16.6	13.0	15.7	15.1	11.1	3.9	5.1	6.7
Bayer 19639, 50 percent carbon.	1	17.0	16.4	16.4	16.6	10.6	3.6	5.4	6.5
Bayer 19639, 50 percent carbon Arasan 75 (*a*).....	1	19.6	17.4	21.1	19.4	10.0	3.2	5.0	6.1
Bayer 19639, 2.5 percent granulated.....	1	19.9	18.1	18.1	18.7	9.7	3.5	5.5	6.2
Control (Kharkof).....		15 2	16.1	19.4	16.9	10.2	3.2	4.1	5.8
Control (Dual).....		13.4	17.2	15.6	15.6	11.5	2.7	6.0	6.7
R.E. at 5 percent level.....		4.1	3.6	5.5	2.6	2.3	1.2	1.8	1.0
R.E. at 1 percent level.....		5.3	4.7	7.1	3.3	3.0	1.6	2.6	2.3

(*a*) Arasan 75 applied at rate of 4 oz. per 100 pounds of seed.

TABLE 5—Weight per plant, percent of plants infested and number of insects per 100 plants from experiment VI, Lapeer County, fall, 1957

Material	Pounds of actual insecticide per acre	Weight per plant (grams)	Percent of plants infested	Number of insects per 100 plants
Planted—August 21				
Thimet, 44 percent carbon.....	¾	7.3	0.3	0.3
Control.....		5.7	17.0	26.3
Significance of difference.....		N.S.	5 percent	5 percent
Planted—September 3				
Thimet. 44 percent carbon.....	¾	3.3	0	0
Control.....		4.7	3.3	5.7
Significance of difference.....		N.S.	N.S.	N.S.
Planted—September 17				
Thimet, 44 percent carbon.....	¾	0.5	0	0
Control.....		1.0	0	0
Significance of difference.....		5 percent		

The plants treated with Thimet in the August 21 seeding were consistently heavier than those in the control but, due to variability, the difference was not significant. In the September seedings the opposite condition prevailed. This apparently was due to a phytotoxi-

city of the insecticide that existed during early growth of the plants but was overcome as the plants developed.

Stand counts in the Lapeer County plots were taken on September 18 from the August 21 seeding. A mean of 7.1 plants per foot was present in the plot treated with Thimet and 9.9 plants per foot in the control, but the difference was not significant at the 5 percent level. No stand counts were made in the September plantings.

The first samples from the Lapeer County plots which were taken to determine the rapidity of disappearance of Thimet had 4.9 p.p.m. of Thimet. The amount of Thimet in the plants continued to decline until only 0.056 p.p.m. was recovered in the fourth sample 44 days after seeding. In the samples taken 57 and 65 days after seeding, no detectable amount of Thimet was found. The Thimet apparently disappeared at a regular rate as shown in Fig. 1.

SUMMARY

Seed and in-row treatments with two systemic insecticides were evaluated for control of the Hessian fly. Both spring and winter wheat were included in the investigation.

The results indicate that:

1. Both Thimet and Bayer 19639 appear to be effective materials for systemic control of this pest on winter wheat.
2. Seed treatments were slightly more effective than in-row applications at comparable rates.
3. Reduction in stand and retardation in early growth were present with several treatments.
4. Generally, there was a complete recovery of the retarded plants followed by increased vigor. This was especially evident in the treatments with Thimet.
5. The addition of a fungicide to the seed treatment lessened the phytotoxicity problem and in some instances eliminated the damage.
6. Residues of Thimet decreased from 4.9 p.p.m. 13 days after seeding to below a detectable amount 57 days after planting.

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COMPARISON OF FUNGICIDES FOR CONTROL OF APPLE SCAB AT PAW PAW

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The 1957 comparison of apple fungicides represents an attempt to determine the effectiveness of several new fungicides for the control of apple diseases. These were compared with commonly used standard materials.

MATERIALS AND METHODS

These spray tests were conducted at the Webb orchard, 3½ miles west of Paw Paw, Michigan. Each treatment was compared on six randomized trees consisting of three each of McIntosh and Jonathan about 16 years old. McIntosh was chosen primarily for its susceptibility to scab; Jonathan was included for its susceptibility to fire blight, and for cedar rust and mildew comparisons. Jonathan is considered somewhat resistant to scab. Scab was the only disease present in significant amounts.

Four new materials were supplied by the Olin Mathieson Chemical Corporation. Zinc Omadine and Omadine disulfide were applied at the rate of ¾ and 1½ pounds per 100 gallons. The two other compounds, furnished under the code numbers of G1122 and G1143, were applied at 2-pound dosages. The material named Cyprex (n-dodecylguanadine acetate), used at 1 and 1½ pound dosages, was supplied by the American Cyanamid Company.

The standard materials used for comparison were Phybam 4 pounds, Ferbam 1½ pounds, Captan 2 pounds, and a combination of Glyodin 1½ pounds and Ferbam ½ pounds. This latter combination was selected because it seemed especially effective in cherry spray experiments. The addition of Ferbam was also expected to prevent injury when lead arsenate was included as an insecticide.

ARTICLE 40-70

APPLICATIONS

The spray treatments applied on a protective schedule were made as follows: (1) Prepink, April 30, (2) Pink, May 6, (3) Petal Fall, May 16, (4) first cover, May 28, (5) second cover, June 10, (6) third cover, June 19, (7) fourth cover, August 5. Insecticides were included in the first, third and fourth cover sprays and in several other solely insecticidal sprays interspersed as needed.

This schedule was expected to keep the trees covered in the early season with a protective fungicide at least 7 days before a rain or throughout 2 inches of rain. On April 24, before the comparative treatments began, all plots were equally sprayed at the green tip stage with 2 gallons per 100 gallons of liquid lime sulphur.

Two eradicative treatments were also applied to test the back action of 1½ pounds of Cyprex in comparison with a known eradicant. The comparative eradicant chosen was 4 pounds of Phybam to which was added an extra dose of ¼ pound of Phygon. Phybam, a proprietary compound, contains the proportion of 3 pounds of sulfur, ¾ pound of Ferbam and ¼ pound of Phygon. Therefore the spray as applied contained a total of ½ pound of Phygon, considered as the effective eradicant constituent.

With the exception of the green tip spray applied by the grower, the eradicant test plots received two sprays only before the first cover; each was applied 48 hours after an infection producing rain. These eradicant sprays were given during early bloom, May 11, and petal fall, May 20. The later treatments applied as protectants to each plot at the first, second, third, and fourth covers were the same, 1 pound of Cyprex, so that the total treatments varied only in the two eradicant sprays.

All sprays were applied with a hand gun at 400 pounds pressure using a 12/64 nozzle disc capable of discharging 18 gallons per minute when fully open. From 10 to 15 gallons of dilute material was required to spray the average tree.

At harvest, 1 representative bushel of apples was picked from each tree and scab was counted. Three categories of scab were considered. Mild scab consisted of an inactive lesion and covered a small area less than ¼ sq. cm. (square centimeters) in area adjacent to an infected sepal. This was relatively inconspicuous and considered of little commercial importance.

Medium scab was a larger area, from ¼ sq. cm. to 1 sq. cm. It was, for the most part, inactive but readily noticeable as a blemish.

Apples showing areas of scab larger than 1 sq. cm. or of active appearance were designated as severe scab and considered culls. The apples showing medium and severe scab were tabulated under one heading as significant scab.

Foliage scab records were not taken. The early infections on the spur leaves were few and scattered. The prebloom and first three cover sprays protected the developing foliage so that foliage scab was not a problem. However, considerable scab infection of small, early formed spur leaves was noticed June 18 on the trees receiving the Phygon eradication spray treatment. These small leaves became conspicuously yellow and soon defoliated.

DISCUSSION OF RESULTS

A protective spray coating should protect the leaves, fruit, and the increasing area of new growth through 2 inches of rainfall or for a period of 7 days. No matter which of these two criteria come first, the tree should be considered vulnerable and the spray treatment should be renewed.

Table 1 presents the timing of the sprays in relation to rainfall. The table shows that the comparative sprays had good timing from prepink to third cover. From final examination it was apparent that very little primary scab was established on the leaves or fruit during this period even on the plots sprayed with materials showing the weakest control. This was due to well-timed renewal of spray residue.

In contrast, the check trees left unsprayed from prepink to petal fall showed 100 percent scab infection on leaves and fruit early in the season which no amount of later spraying could correct.

Sepal Scab

Observations indicate that sepals are infected only in the silver tip through the green tip stage. All the mild scab infection and most of the medium and severe scab recorded in Tables 2 and 3 were adjacent to and apparently spread from infected sepals. Very few of the severely scabbed areas resulted directly from primary spores. Almost all of the fruit infection could be traced to secondary spread from the sepals.

It seems apparent that the sepal scab was established before comparative sprays were first applied. Also, the most effective treatments were those that best prevented the growth and spread of established sepal scab. It would be expected then, that efficient timing

TABLE 1—Rainfall and spray dates, Paw Paw, 1957

Date	Rainfall	Spray applied	Date	Rainfall	Spray applied	Date	Rainfall	Spray applied
April	Inches		June	Inches		July	Inches	
16	.22		1	.06		17		
17			2			18		
18			3			19		
19	.08		4			20		
20	.06		5			21		
21			6			22	1.30	
22	.08		7	.08	Second	23	.04	
23	.38	Lime Sulfur	8		cover	24		
24	.59	←	9		←	25		
25	.25	Green Tip	10			26		
26	.28		11	.43		27		
27	.83		12			28		
28	.01		13	.26		29		
29			14	.02		30		
30		Prepink	15			31		
May		←	16			Aug.		
1			17	.50		1		
2			18	.05	Third	2		Fourth
3			19		cover	3	.94	cover
4			20		←	4		←
5			21			5		
6		Pink	22	.22		6		
7		←	23			7	.02	
8			24			8	.03	
9	.05	First	25			9		
10	.40	eradicant	26			10		
11	.56	←	27	.11		11		
12			28	.85		12		
13			29			13		
14	.06		30	.04		14	.37	
15		Petal Fall	July			15		
16		←	1	.06		16		
17	.08		2			17		
18	.10	Second	3			18		
19	1.28	eradicant	4			19		
20	T (*a*)	←	5			20		
21			6			21		
22	.09		7	.08		22		
23	.05		8			23	T	
24			9			24	1.34	
25	.19		10			25		
26	.01		11	.43		26		
27		First cover	12			27		
28		←	13	.26		28	.25	
29			14	.02		29	.13	
30			15			30	1.36	
31			16			31	.	

(*a*) Trace.

TABLE 2—Comparative scab control for materials tested on McIntosh apples, 1957

Materials	Dosage/100 gal.	Fruits number	Mild scab percent	Medium scab percent	Severe scab percent	Significant scab percent
Cyprex (*a*)	1½ lb.	279	1.1	1.8	2.5	4.3
Cyprex	1 lb.	273	4.0	5.1	0.0	5.1
Phybam-Phygon (*a*)	4 lb.-¼ lb.	226	2.2	4.0	3.1	7.1
Omadine disulfide	1½ lb.	254	5.9	7.9	1.6	9.5
Phybam	4 lb.	218	4.6	8.3	1.8	10.1
Glyodin-Ferbam	1½ pt.-½ lb.	289	3.0	8.0	2.8	10.8
Captan	2 lb.	181	1.7	8.8	2.2	11.0
G1143	2 lb.	268	4.8	9.7	5.2	14.9
Ferbam	1½ lb.	292	2.2	8.9	7.5	16.4
Zinc Omadine	1½ lb.	288	2.8	9.7	7.6	17.3
Zinc Omadine	¾ lb.	242	5.8	12.0	7.0	19.0
G1122	2 lb.	272	1.8	10.3	8.8	19.1
Omadine disulfide	¾ lb.	267	3.3	12.3	11.6	23.9

(*a*) Two precover sprays only, applied as eradicants. Cover sprays 1 lb. Cyprex with regular timing.

TABLE 3—Comparative scab control for materials tested on Jonathan apples, 1957

Materials	Dosage/100 gal.	Fruits number	Mild scab percent	Medium scab percent	Severe scab percent	Significant scab percent
Cyprex (*a*)	1½ lb.	432	2.1	0.7	0.0	0.7
Cyprex	1 lb.	453	0.7	0.9	0.0	0.9
Phybam	4 lb.	414	5.8	3.6	0.0	3.6
G1143	2 lb.	280	3.6	2.9	2.7	3.6
Phybam-Phygon (*a*)	4 lb.-¼ lb.	409	3.9	4.2	0.0	4.2
Captan	2 lb.	297	4.7	6.4	1.0	7.4
Zinc Omadine	1½ lb.	435	11.2	6.9	0.7	7.6
Omadine disulfide	1½ lb.	424	5.2	7.8	0.0	7.8
Glyodin-Ferbam	1½ pt.-½ lb.	299	9.7	7.7	1.3	9.0
G1122	2 lb.	444	7.4	8.6	4.9	9.5
Omadine disulfide	¾ lb.	456	8.5	11.6	1.8	13.4
Ferbam	1½ lb.	415	10.6	12.3	1.7	14.0
Zinc Omadine	¾ lb.	383	8.9	13.8	0.5	14.3

(*a*) Two precover sprays only, applied as eradicants. Cover sprays 1 lb. Cyprex with regular timing.

and thoroughness in the application of sprays in the early green tip stage, with more control of sepal infection, would have resulted in a lesser contrast among materials in the final results.

There is little doubt from the results of this experiment that Cyprex, even at the 1 pound dosage, was markedly superior to the

other materials tested for scab control. However, the use of this material resulted in severe russeting on a small percentage of McIntosh. This is disturbing for the exact conditions under which russeting occurs were not determined. The barely adequate control of the standard materials such as Phybam, Glyodin, Captan, and Ferbam indicate these materials allow little liberty in timing.

On McIntosh, Omadine disulfide at 1½-pound dosage appeared equivalent to the standard dosages of Phybam, Glyodin, and Captan. Between these materials there was little difference in control. The other treatments, including Ferbam and the lighter dosages of the Omadine compounds, were decidedly inferior. The ranking of the treatments differs somewhat on Jonathan but shows little improvement except with G1143 at the 2-pound dosage.

Russeting Resulting from Cyprex

Russeting on Cyprex sprayed trees was particularly noticeable for the 1½-pound dosage and comprised about 1 percent of the fruits on the McIntosh variety. It consisted of severely russeted and cracked areas covering several sq. cm. There was little intermediate damage. The fruit was either so severely russeted that it was considered a cull or it was completely free from russet. Such russeting was not seen on Jonathans but there was more basin-end roughness on Cyprex sprayed Jonathans than on those receiving the other sprays.

It is conceivable that the severe russeting of Cyprex resulted from a complex of spray and frost injury. It was impossible to determine whether the more severe russeting resulted from the larger dosage or the timing, as the two treatments on the Cyprex sprayed trees varied in both timing and dosage.

Most of the available fungicides will give satisfactory control of apple scab if applied with sufficient frequency and adequate dosage. Conversely, any material may fail if it is applied with unfavorable timing or inadequate dosage.

Experimental comparisons evaluate the materials under a particular set of conditions. A continuous study of such experimental results should help the grower and investigator to determine the limitations of the different fungicides and under what conditions they are most useful. These results are a part of a continuing program and no definite conclusions are presented.

COMPARISON OF FUNGICIDES FOR CONTROL OF CHERRY LEAF SPOT IN 1956 AND 1957

By DONALD CATION

Department of Botany and Plant Pathology

Experimental comparisons of old and new materials for the control of cherry leaf spot (*Coccomyces hiemalis*) are conducted yearly in Michigan. These tests lead to a better understanding of what to expect from materials under different seasonal conditions.

The spray program for control of leaf spot has developed over the years by trial and error. Considerable knowledge has been accumulated regarding conditions favoring the fungus and the effects of various fungicides.

In early years, a few sprays of long lasting materials such as Bordeaux 8-12-100, applied in strong doses, contained the disease. However, they also harmed the plants and forced a trend toward milder materials. Since milder materials had less tenacity and residual life than Bordeaux, more sprays were needed. Even though the milder fungicides left the foliage in a better condition, they were unsatisfactory because they lacked the desired control. This was especially true when conditions were favorable to the fungus or when poorer sticking materials were exposed to repeated rains.

Light primary infection is sometimes established during bloom. A continuous spray coverage during the first 25 to 30 days following petal fall is expected to hold primary infection to such a minimum that secondary infection can not build up before the fruit is packed.

Another spray after harvest is expected to prevent infections from repeating. It also keeps the disease from increasing during the late summer and fall rains. The goal of clean foliage held to the end of the season is not always reached with some materials and in some years the disease requires more rigorous treatments.

The years 1956 and 1957 represent rather extreme contrasts and

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materials showed wide variation in control. The results obtained in those years are presented here along with charts showing the relationship between rainfall and timing of spray applications.

TABLE 1—Materials used in 1956 and 1957; and their sources

Materials	Sources
Omadine Mn (2-pyridinethione 1-oxide, Manganese salt) 50 percent W.P. Omadine Cu (2-pyridinethione 1-oxide, copper salt) 50 percent W.P. Omadine Zn (2-pyridinethione 1-oxide, zinc salt) 50 percent W.P. Omadine disulfide (2-pyridinethione 1-oxide disulfide) 50 percent W.P. (*a*) G1143—chemical formula not given. (*a*) G1142—chemical formula not given. (*a*)	Olin Mathieson Chemical Corp.
Cyprex (n-dodecylguanadine acetate) 50 percent W.P.	American Cyanamid Co.
Glyodin (2-butadecyl-2-imodaxiline acetate)	Union Carbide Chemicals Co.
Ferbam (ferric dimethyldithiocarbamate) 76 percent W.P.	E. I. DuPont de Nemours and Co, Grasselli Chemicals Dept., and others.
Captan (N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide) 50 percent W.P.	California Spray Chemical Corp. and Stauffer Chemical Co.
Fixed copper (Basic copper sulfate) 26 percent W.P.	Tennessee Copper Co. and others.
Bordeaux (reaction of copper sulfate and calcium hydroxide) Spray lime (calcium hydroxide plus magnesium hydroxide)	Local distributors
Actidione (3- 2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxy-ethyl glutarimide) Semicarbazone (semicarbazone analogue of Actidione)	The Upjohn Co.
Corona Spray Conditioner (Modified phthalic glycerol alkyd resin) Phybam-S (2,3-Dichloro-1,4-Naphthoquinone) 3 percent, (Ferric Dimethyl dithiocarbamate) 9.5 percent, (Sulfur) 71.0 percent (*a*)	Pittsburgh Plate Glass Co., Corona Chemicals Division
Triton B1956 (Modified phthalic glycerol alkyd resin)	Rohm and Haas Co.
Phygon (2,3-dichloro-1,4-naphthoquinone) 50 percent W.P. (*a*)	U. S. Rubber, Naugatuck Chemical Division

(*a*) These materials were used only in apple tests in 1957; refer to article 40-70, p. 603.

MATERIALS AND METHODS

The experimental test plots were established at the Point Sable Orchards, 7½ miles west of Shelby and 2 miles inland from Lake Michigan. The materials compared on cherries and apples and the companies supplying them are listed in Table 1.

The standard comparison was made with a minimum four-spray program. This consists of three preharvest sprays, spaced approximately 10 days apart, which begin at petal fall. A fourth spray is applied as soon as possible after harvest. Several materials were compared in a three-spray schedule in 1956, omitting the after-harvest spray. Tests of materials applied as single sprays just prior to harvest were also made in 1957.

Materials tested in the regular four-spray program were applied to single trees replicated five times in random distribution. [Each spray was applied from the ground with a spray gun at 400 pounds pressure.] An attempt was made to wet every leaf. Entire rows in the single spray tests were sprayed from the spray machine.

Also in 1957, two materials were tested using a 6X concentration (6 times the normal concentration) and applied with a mist blower. Two pounds of arsenate of lead were added to each 100 gallons of spray in the regular preharvest applications. This is standard insecticidal practice in Michigan.

Evaluation of control or injury was obtained by observations throughout the season and by counting the leaves missing near the end of the season. In 1956 the leaves missing from spur growth were counted; in 1957 the leaves missing from terminal growth were considered in the final evaluation.

Experiments in 1956

The materials used in the 1956 spray treatments and the results as represented by the final spray count are given in Table 2. Four treatments consisting of Cyprex at both the 1½-pound and 1-pound dosages, the Glyodin-Ferbam combination, and the fixed copper and lime spray controlled leaf spot completely in that year. The leaves lost from the copper-sprayed trees were entirely the result of injury.

Ferbam and Captan were on the margin of successful control. Trees sprayed with these materials showed considerable infection and foliage loss which is reflected in the final count.

The weaker dosages of Omadine Manganese failed, but the 2-pound dosage gave results equal to Ferbam in this experiment.

TABLE 2—Comparison of cherry leaves lost from spurs following different spray treatments, Shelby, Michigan, September 23, 1956

Materials used	Dosage, per 100 gal.	Av. leaves lost from spurs, percent
Cyprex.....	1 lb.	0.6
Cyprex.....	1½ lb.	0.8
Glyodin-Ferbam....	1½ pt., ½ lb.	0.8
26 percent Copper-lime.....	3 lb., 3 lb.	6.2
Captan.....	2 lb.	11.9
Ferbam.....	1½ lb.	22.1
Omadine Mn.....	2 lb.	24.2
Omadine Mn.....	1 lb.	54.8
Omadine Mn.....	½ lb.	43.7

Several alternate sprays of Actidione and Glyodin compared in 1956 gave satisfactory final results as indicated in Table 3. As no infection was detected on these trees at harvest time, an after-harvest treatment was not given.

TABLE 3—Comparison of cherry leaves lost from spurs following three preharvest treatments containing Actidione, Shelby, Michigan, September 23, 1956

Materials used	Dosage, per 100 gal.	Spray applied	Av. leaves lost from spurs, percent
Glyodin.....	1½ pt.	1st and 2nd	...
Actidione.....	2 p.p.m.	3rd	3.2
Glyodin.....	1½ pt.	1st	...
Actidione.....	1 p.p.m.	2nd and 3rd	4.6
Actidione.....	2 p.p.m.	1st, 2nd, and 3rd	3.4

Timing in Relation to Rainfall in 1956

Certain seasonal conditions encountered are considered in the relation of timing and rainfall presented in Table 4. In the 1956 season, the petal-fall spray was applied on June 8. It was required to protect the plants through 2.64 inches of rain that fell 8 and 9 days later. The first cover spray was required to protect the plants for 15 days.

This may be too long an interval for this period of rapid, unprotected new growth.

TABLE 4—Rainfall and spray applications, Shelby, Michigan, 1956

Date	Rainfall	Spray applied	Date	Rainfall	Spray applied	Date	Rainfall	Spray applied
May	Inches		July	Inches		Aug.	Inches	
26	.03		5	.38	Second cover	17		
27	.05		6		←	18		
28			7			19		
29	.32		8	.20		20		
30	.53		9	.40		21	.12	
31			10			22		
			11			23	.36	
June			12	.16		24		
1			13	.10		25		
2			14	.03		26		
3			15			27	.49	
4			16			28		
5			17			29		
6			18			30	.20	
7		Petal fall	19	.40		31		
8		←	20	.16				
9			21			Sept.		
10			22			1		
11			23			2		
12			24			3		
13			25	.55		4		
14			26			5		
15			27			6	.40	
16	.40		28			7		
17	2.24		29			8	.23	
18			30			9		
19			31			10		
20		First cover				11		
21		←	Aug.			12		
22			1			13		
23			2					
24			3		After harvest			
25			4	1.20	spray			
26	.12		5	.12	←			
27	.16		6					
28	.08		7					
29			8					
30			9					
			10					
July			11	.45				
1	.44		12					
2			13					
3			14	.07				
4	.02		15	.15				
			16					

The second cover spray was required to protect for 30 days and through 3.52 inches of rain before the final spray renewal. Such conditions are not unusual but they put a strain on the protectivity of Ferbam, Captan, and the Omadine Manganese salt. Trees sprayed with these materials were showing slight lack of control as indicated by the infected yellow leaves showing on July 21.

Further infection and defoliation occurred later in the season, but trees sprayed with these treatments finally reached the end of the season with a fair amount of foliage and the treatments would be considered commercially practical. However, the trees sprayed with the weaker dosages of Omadine Manganese showed severe infection and defoliation by mid-August.

Experiments in 1957

The materials tested in 1957 using a four-spray schedule together with the final defoliation counts are listed in Table 5. The timing of the sprays in relation to rainfall is given in Table 6.

A small amount of infection occurred during bloom before spraying started. Other than this, the first three sprays were well-timed to prevent infection from the primary spores, assuming that primary spore discharge was complete by June 26. All new infections after that time would come from secondary spores produced in lesions that had not been prevented or from which the fungus had not been eradicated by the three previous sprays.

TABLE 5—Comparison of leaves lost from terminal growth of Montmorency cherry trees following different treatments, October 4, 1957

Materials	Dosage, per 100 gal.	Leaves lost, percent
Cyprex	1 lb.	3.3
Cyprex	½ lb.	5.4
Glyodin-Ferbam	1½ pt., ½ lb.	40.0
Glyodin-iron sulfate	1½ pt., ½ lb.	64.0
Omadine-copper salt	1½ lb.	55.5
Actidione-Ferbam	1 p.p.m., 1½ lb.	57.0
Fixed copper-lime	3 lb., 3 lb.	67.0
Captan	2 lb.	....(*a*)
Ferbam	1½ lb.	....(*a*)
Omadine-zinc salt	1½ lb.	....(*a*)

(*a*) Failed and removed from experiment after harvest.

TABLE 6—Rainfall and spray applications, Shelby, 1957

Date	Rainfall	Spray applied	Date	Rainfall	Spray applied	Date	Rainfall	Spray applied
May	Inches		June	Inches		Aug.	Inches	
10	.49		22	.45		1		
11	.02		23	.09		2		
12			24			3		
13	.02		25	.43		4		
14			26	.95		5		
15	.78		27			6		
16			28	1.20		7		After harvest
17	.08		29			8		←
18	.04		30	.03		9	.02	
19	.45					10		
20			July			11		
21	.03		1			13		
22	1.05		2			14		
23	.40		3	1.18		15	.88	
24		Petal fall	4			16		
25	.11	spray	5			17		
26	.03	←	6	1.12		18		
27			7			19		
28			8	.55		20		
29	.02		9			21		
30			10			22		
31			11	.82		23	.12	
			12	.97		24	.10	
June			13	.20		25		
1			14			26		
2			15			27		
3(*a*)			16			28	.10	
4		First cover	17			29	.02	
5		←	18			30	.05	
6			19			31	1.31	
7			20					
8			21	.05				
9			22	1.10	Extra sprays			
10			23		←			
11			24					
12	.18		25					
13	1.00		26					
14	.05		27					
15	.04		28					
17		Second cover	29					
18		←	30					
19			31					
20								
21								

(*a*) First infections seen.

If the primary infections were not well controlled, the second cover spray was required to protect through 8 inches of rain that fell

on 14 of 30 days between June 22 and July 22. Some of the materials controlled leaf spot regardless of these exacting conditions. Other materials failed.

Successful control might be attributed to the complete suppression of primary infection so that no secondary spores were present when the spray residues were at a minimum. Another possibility is that the successful materials maintained a protective residue throughout the exposure to 8 inches of rain.

It was apparent that the unsuccessful treatments met neither of these two objectives completely, for secondary spores were present and sufficient protective residue was not maintained. Infections were known to occur during the July 12 to 14 infection period. Yellow leaves and fresh lesions on green leaves were evident on July 20. Infections again multiplied during the July 21-22 rains. Captan, Ferbam, and the Omadine-Zinc treated trees had so much infection at harvest time that they were removed from the experiment and sprayed with Actidione at the rate of 2 p.p.m. in the after-harvest spray.

The treatments that brought the trees through the harvest period with little or no infection were Cyprex, the Glyodin-Ferbam combination, the Ferbam-Actidione combination, Omadine Copper, and fixed copper and lime. The Glyodin-iron sulfate combination was showing a light scattering of infection at harvest.

The after-harvest treatments applied on August 8 were expected to protect for the rest of the season. How long and well a material protects after harvest depends on the amount of earlier control, the tenacity and fungicidal properties of the materials, the amount of rain, and the number of infection periods occurring during the late summer and fall. The total effect of each material in aiding the tree to hold its leaves throughout the season is reflected in the final leaf count presented in Table 5.

Of the materials used, Cyprex at both the 1-pound and ½-pound dosages showed remarkably little foliage loss under the exacting conditions of 1957. The Glyodin-Ferbam combination treatment gave practical control even though the terminal foliage count showed an average 40 percent loss at the late date of the foliage count. The half pound of Ferbam added to the Glyodin for correction of lead arsenate injury gave better leaf spot control than the Glyodin and iron sulfate combination.

The combination of 1 p.p.m. of Actidione and 1½ pounds of Ferbam was effective in leaf spot control but was markedly injurious to

young tender leaves. The combination appears synergistic—each material increasing the potential activity of the other. It is not recommended because of the injury factor.

Copper Omadine was superior to the fixed copper and lime spray in these tests but both showed rather continuous defoliation throughout the season as a result of injury. The injury from fixed coppers was more serious than is generally experienced.

Experiments With Concentrate Sprays in 1957

Cyprex and the Glyodin-Ferbam combination were compared in a large scale test on 30-year old trees using a 6X concentration. For example, a concentrated dosage of 6 pounds of Cyprex per 100 gallons was applied at the rate of 0.7 gallon per tree with an air blast sprayer instead of the normal dosage of 1 pound per 100 gallons applied at the rate of 4 gallons per tree with a hand gun. The equivalent concentrated dosage for the Glyodin-Ferbam combination was 9 pints of Glyodin and 3 pounds of Ferbam per 100 gallons.

Both concentrate treatments controlled leaf spot under the exacting conditions of 1957. At no time during the season were infections found on the Cyprex-sprayed trees. A trace of infection could be observed at harvest time and again late in the season on the Glyodin-Ferbam-sprayed trees, but since no serious defoliation resulted, both treatments were considered successful.

Applications On Trees Showing Preharvest Infections

Trees approaching harvest with a noticeable sprinkling of infection and with residual spray protection depeleted are frequently encountered in commercial practice. The only preventatives of further spread of the fungus and disastrous wholesale defoliation are (1) another protective spray, (2) a fortunate lack of further infection periods before the after-harvest spray, or (3) a back-action spray if another infection period occurs.

An opportunity to compare the effectiveness of several materials in such a case was presented on July 24, just prior to harvest and 2 days after an infection period. Different spray treatments were given to entire rows of 9-year old and 3-year old trees.

On the 9-year old trees, Actidione, 2 p.p.m. plus B1956, 2 ounces; Cyprex, 1½ pounds; and Cyprex, 1 pound were compared. The immediate effect observed 2 weeks later indicated that Actidione stopped the activity in the established lesions and prevented new infections.

Cyprex was considered to have failed in this instance as the Cyprex-sprayed trees were showing many yellow leaves.

The long range effect was reversed. Following the late August rains, leaf spot infections again appeared and multiplied progressively on the Actidione-sprayed trees. These were defoliated by October 14. Leaf spot did not build up on the Cyprex-sprayed trees which were in good foliage in mid-October.

On the 3-year old trees, Actidione, 2 p.p.m. plus Corona Spray Conditioner, 4 ounces; Cyprex, ½ pound plus Actidione, 1 p.p.m.; and Bordeaux 4-6-100 failed to give lasting control. In the first case, the amount of Actidione in contact with the leaf may have been reduced by the addition of a wetting agent. A thinner film and a smaller amount of liquid remaining on a leaf (reducing the Actidione deposit) would result from a lowered surface tension.

In the second case, Cyprex and Actidione appear incompatible. Lastly, Bordeaux 4-6-100 gave early injury which increased as the season advanced. As immediate injury is not characteristic of well prepared Bordeaux, the quality of the lime used was under suspicion.

The materials that gave satisfactory immediate and lasting control were Glyodin, 1½ pints plus Actidione, 1 p.p.m.; Ferbam, 1½ pounds plus Actidione, 1 p.p.m.; Glyodin, ½ pint plus Actidione, 2 p.p.m.; and the semicarbazone analogue of Actidione at both 2½ and 5 p.p.m.

SUMMARY AND CONCLUSIONS

Of the materials tested in a full season schedule, Cyprex at both 1 pound and ½ pound per 100 gallons exceeded other materials in control of cherry leaf spot under exacting conditions.

A combination of Glyodin and Ferbam gave equal control with Cyprex in an average year and second best in 1957, a year of more rainfall.

The fixed copper spray with the addition of lime controlled the disease but resulted in more than usual injury in both years.

Ferbam and Captan failed to control through extended periods and large amounts of rainfall. Under such conditions these two materials need more frequent applications to give control equivalent to the other materials used.

The Omadine compounds could be used for cherry leaf spot control but they showed no advantages over presently available materials.

In two instances, wetting agents retarded the overall effectiveness of Actidione. Actidione and some of its analogues are the only ma-

terials yet known to exhibit appreciable back action for cherry leaf spot infections. The semicarbazone analogue of Actidione showed promise for use in leaf spot control.

Cyprex and the Glyodin-Ferbam combination controlled leaf spot in 6X concentrate applications.

All of the available standard materials are of value for cherry leaf spot control. The requirements for the renewal of protective residue vary with the material, the season, the stage of tree growth, and the potential inoculum. To achieve successful control in all seasons, a grower must either have an understanding of the requirements for controlling the disease or blindly follow a fixed schedule of a maximum number of applications that will meet any set of conditions.

THE INTERRELATIONSHIP OF TEMPERATURE AND PESTICIDE CHEMICALS AS AFFECTING THE FINISH OF GOLDEN DELICIOUS APPLES

By DALE W. KRETCHMAN and ARTHUR E. MITCHELL

Department of Horticulture

Freezing temperatures have long been considered a primary cause of apple russeting (Dorsey 1918, MacDaniels, et al. 1930). The advent of organic pesticides revived interest in this problem. Studies centered on both freezing temperatures and the influence these organic chemicals had on fruit russeting.

Early work by Morse (1918) and Dutton (1932), and later studies by Palmiter (1944) and Garman (1951) pointed out that the russeting of some varieties of fruit may result from the use of such chemicals as sulfur, copper, and arsenic under certain weather conditions.

Recent reports by Mitchell (1951-55) suggest that slight russeting of the fruit when the air temperature dropped to 32° F. or lower near the period of full bloom, was increased to severe injury when certain pesticides were used after the occurrence of the low temperature. Furthermore, he indicated that no russeting of the fruit occurred when the same pesticide chemicals were used in seasons when the air temperature remained above 32° F.

Since the fruit of the Golden Delicious variety has been reported very sensitive to both chemical and cold injury (Palmiter 1944, Mitchell 1952), a study was initiated to determine the relationship between cold injury and the use of certain pesticide chemicals on fruit russeting. The findings of this study are reported herein.

MATERIALS AND METHODS

To isolate the factors, freezing temperature and fungicide, as they influence fruit russeting, polyethylene cages[1] with removable panels

[1] The cages were made with 0.002-inch polyethylene obtained through the courtesy of the Bakelite Division of Union Carbide Corporation.

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were built around two 4-year-old bearing Golden Delicious apple trees growing on Malling VII root stocks. One tree was enclosed only on those nights near full bloom when the air temperature was predicted to drop to 32° F. or lower. The second tree remained exposed. The air temperature surrounding the enclosed tree during these nights was maintained above 32° F. with electric heaters. Both trees were exposed at other times during the growing seasons.

The trees were pruned to divide the bearing surfaces into two distinct halves so that two fungicide treatments could be evaluated in the same environment.

The treatments expressed as amounts per 100 gallons of spray mixture were as follows:

Three applications of Phix (Phenylmercuric acetate) at 4 ounces plus wettable sulfur at 3 pounds were made uniformly on all trees prior to early pre-pink.

Beginning with early pre-pink, eight applications of the comparison treatments of captan (N-trichloromethylmercapto-4-4 cyclohexene-1, 2-dicarboximide) at 2 pounds and glyodin (2-heptadecylglyoxalidine acetate) at 1 fluid quart were made on one-half of each of the trees. The captan served as the control treatment.

At petal fall, 2 pounds of methoxychlor [1, 1, 1-trichloro-2, 2-bis (paramethoxyphenyl) ethane] were used uniformly in the last four fungicide applications. Five additional sprays of 2 pounds methoxychlor were necessary in July and August for insect control.

A separate single application of 25 percent wettable malathion [S-(1, 2-dicarbethoxyethyl) 0, 0-dimethyl dithiophosphate] at 2 pounds plus 4 fluid ounces of Triton B-1956[2] as a wetting agent was made between the second and third cover sprays to control green apple aphids (*Aphis pomi*, DeGeer).

All applications beginning with early pre-pink were made with a motor-powered wheelbarrow sprayer operating at 150 pounds pressure equipped with a hand gun. A curtain was used to separate the halves of each tree while applying the fungicide treatments to avoid contamination from drift.

To further check the influence of fungicides on russeting, a 30-year-old Golden Delicious tree located approximately 500 feet from the two treated trees was divided into two equal halves and sprayed in the same manner just described. An adjustable nozzle gun, attached

[2] A phthalic glycerol alkyd resin, obtained through courtesy of the Rohm and Haas Company.

to a sprayer equipped with a 20-gallon per minute pump operating at 400 pounds pressure, was used to make these applications.

During the early morning hours of May 24, 1956, 3 days after full bloom, the air temperature dropped to 28° F. for approximately 45 minutes. One tree was protected against temperatures below 33° F. by enclosing it during the night (Fig. 1) and using electrical heaters. This served as the control tree. It was assumed that the air temperature dropped to approximately 28° F. in the vicinity of the 30-year-old Golden Delicious tree since it was only 500 feet from the other trees and its elevation was about the same.

Fig. 1. Polyethylene cages with removable panels enclosing apple trees growing on dwarfing rootstocks.

Records on the presence or absence of russeting of the harvested fruit were obtained from a ½-bushel sample from each treated portion of the trees on dwarfing stocks; and from a 7-bushel sample from each treated portion of the 30-year-old tree.

RESULTS AND DISCUSSION

The comparison of the fruit russeting resulting from the two fungicide treatments and from exposure to the air temperature of 28° F. 3 days after full bloom are illustrated in Figs. 2 and 3. The data of fruit russeting resulting from these two factors, fungicides and low temperature, are shown in Table 1.

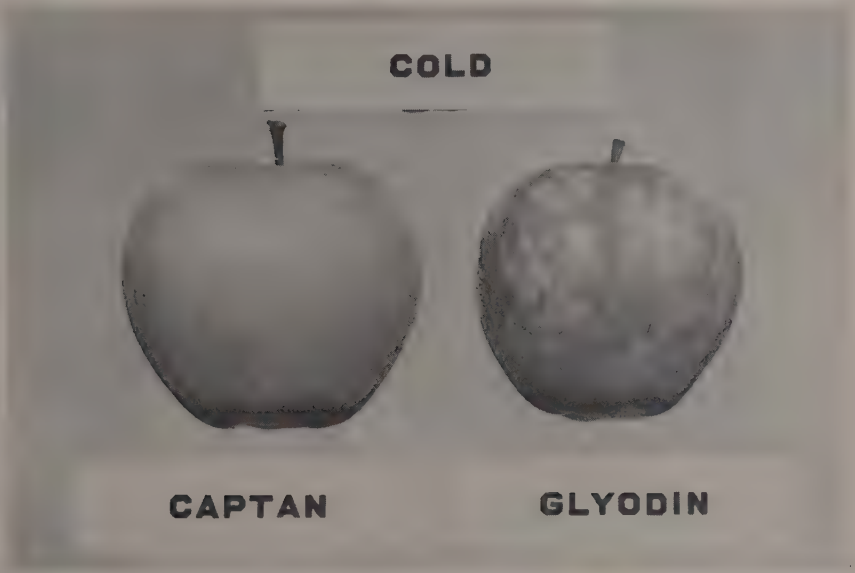

Fig. 2. A representative sample of apples taken from the tree exposed to an air temperature 28° F. 3 days after full bloom and sprayed with captan and glyodin.

Fig. 3. A representative sample of apples taken from the tree protected from the freezing temperature of May 24, 1956 and sprayed with captan and glyodin.

TABLE 1—Relationship of Golden Delicious apples to the use of certain fungicides following exposure to air temperatures of 33° F. and 28° F. occurring 3 days after full bloom, East Lansing, 1956

Treatment	Free of russeting (percent)	Light(*a*) russeting (percent)	Heavy(*b*) russeting (percent)
Exposure to 28° F.			
Glyodin	0	15.5	84.5
Captan	2.7	72.9	24.4
Exposure to 33° F.			
Glyodin	0	72.2	27.8
Captan	56.8	43.2	0

(*a*) Light russeting—fruit only lightly russeted qualified for U.S. Fancy and U. S. No. 1 grades as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).
(*b*) Heavy russeting—sufficient to reduce the grade of the fruit below U.S. No. 1 as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).

The results of the half-tree fungicide treatment made on the 30-year-old Golden Delicious tree are given in Table 2.

TABLE 2—Russeting of Golden Delicious apples due to exposure to a freezing temperature of approximately 28° F. 3 days after full bloom and to the use of certain fungicides, East Lansing, 1956

Treatment	No russeting (percent)	Light(*a*) russeting (percent)	Heavy(*b*) russeting (percent)
Glyodin	0	3.5	96.5
Captan	9.9	64.6	25.5

(*a*) Light russeting—fruit only lightly russeted qualified for U.S. Fancy and U.S. No. 1 grades as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).
(*b*) Heavy russeting—sufficient to reduce the grade of the fruit below U.S. No. 1 as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).

In preliminary studies, Mitchell (1954) found that the use of glyodin on Golden Delicious during the period "pre-pink" through "second cover" resulted in an excessive number of russeted fruits even in seasons when the air temperature remained above 32° F.

He reported also (1954) that in some years, even though captan was the only fungicide used throughout the season, russeting occurred on Golden Delicious. This happened in seasons when the air temperatures fell below 32° F. either just before or just after full bloom. He concurred that the russeting was a result of cold injury to the fruit and not to the use of captan. The fact that 23.7 percent of the fruits from the treatment 28° F. plus captan were heavily russeted as compared to no heavy russeting for the treatment 33° F. plus captan appears to substantiate this premise (Table 1).

These results tend to throw some light on the factors responsible for fruit russeting on Golden Delicious apples. As all treatments were made on half-trees, the environmental conditions were as similar as possible with the only apparent variable being air temperature. Nevertheless, the portions of the trees sprayed with glyodin and protected against possible injury from cold still produced fruit with some degree of russeting. Moreover, the use of glyodin on the fruit exposed to an air temperature lower than 32° F. 3 days after full bloom resulted in an even larger number of fruits exhibiting both light and heavy russeting (Table 1).

When comparing fruits from the same Golden Delicious tree sprayed with different fungicides, the use of captan resulted in a much smaller percentage of fruits either heavily russeted or lightly russeted and a larger percentage of fruit completely free of russeting than was found from the use of glyodin (Table 2). In fact, the data of the captan treatment in Table 2 are very similar to the data of the glyodin treatment made on the tree protected against exposure to freezing temperature (Table 1). Also, the amount of heavy russeting occurring from the glyodin treatment made on the tree unprotected from the freezing temperature recorded in Table 1 is very similar to the amount found on the half-tree treatment of glyodin made in the field (Table 2).

From the previously reported data of heavy fruit russeting resulting from the use of different pesticide chemicals (Mitchell 1952-55) and that found in Tables 1 and 2, it may be stated that air temperatures of freezing (32° F. or below) cause some fruit russeting which may be greatly increased from the use of certain pesticide chemicals. Even though unfavorable on Golden Delicious under the conditions of this study, data from concurrent work in 1956 (Table 3) indicate that glyodin may be used advantageously on such apple varieties as Red Delicious and McIntosh. This substantiates previous findings (Mitchell 1954-55).

TABLE 3—Influence of captan and glyodin on fruit russeting of various varieties of apples when no freezing temperatures were experienced near bloom; Michigan State University, Graham Experiment Station, 1956

Variety	Fungicide	Light(*a*) russeting (percent)	Heavy(*b*) russeting (percent)
Red Delicious.....	Captan.....	0.8	0.1
	Glyodin....	0.3	0
McIntosh.....	Captan.....	1.5	1.8
	Glyodin....	1.1	1.3

(*a*) Light russeting—fruit only lightly russeted qualified for U.S. Fancy and U.S. No. 1 grades as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).

(*b*) Heavy russeting—sufficient to reduce the grade of the fruit below U.S. No. 1 as defined by Michigan Apple Marketing Law (Act 132, P.A. 1937).

The only known means of determining which chemicals may be used safely on each variety under various environmental conditions is by trial and error. Further studies relative to these factors are in progress.

SUMMARY

1. To isolate the factors, freezing temperature and fungicides, which contribute to fruit russeting, electrically heated polyethylene cages with removable panels were built around two 4-year-old bearing Golden Delicious apple trees growing on Malling VII rootstocks. On May 24, 1956, the temperature fell to 28° F. for 45 minutes. One tree was protected while the other remained exposed.

2. The trees were pruned to divide the bearing surfaces into two distinct halves so that two fungicide treatments, captan and glyodin, could be evaluated in the same environment.

3. For additional observations, a 30-year-old Golden Delicious tree located approximately 500 feet from the two treated trees was similarly divided into two equal halves and sprayed in the manner just described.

4. At harvest time, the portion of the tree protected against exposure to the air temperature of 28° F. and receiving the glyodin treatment had 27.8 percent of the fruit heavily russeted. The portion treated with captan had no fruit so affected. On the tree exposed to

the low of 28° F., 84.5 percent of the fruit treated with glyodin was heavily russeted. This compares to 24.4 percent for the captan treatment.

5. Similar results were obtained from the harvested fruit of the 30-year-old Golden Delicious tree exposed to the approximate low of 28° F. The portion treated with glyodin had 96.5 percent heavily russeted fruit compared to 25.5 percent for that treated with captan.

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RESULTS OF FIELD EXPERIMENTS WITH NEW INSECTICIDES AND ACARICIDES ON MICHIGAN FRUIT

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DURING THE POST-WAR YEARS fruit growers have depended largely on DDT and parathion as standard insecticides in the majority of spray programs. Because insects and mites have the ability to develop tolerances to some pesticides, growers have found it increasingly difficult to control some of the major insect pests.

Evidence of partial resistance to DDT by codling moth, to DDD by red-banded leaf roller, and to parathion by mites has been demonstrated in several sections of the country including Michigan. Although it is difficult to predict future resistance problems, it would be logical to assume that eventually all insects will be tolerant to continuous usage of the same materials.

Other pest control problems have evolved and become progressively complex during the past decade. Some of these are chemical toxicities to the operator, residues at harvest, and increased cost of pest control. As a result, insecticide manufacturers, research chemists, and entomologists are constantly faced with the tremendous task of producing and evaluating new compounds which will satisfy all of these requirements. In addition, they must make it possible for growers to continue marketing both quantity and quality fruit.

Since 1956, the department of entomology has been conducting an intensified research program to determine which of the new experimental pesticides would best fit the growers' needs and still be within his budget. The following tables and discussion form a condensed resume of the performance of the more promising materials during this period.

EXPERIMENTAL PROCEDURE

In general, research plots were established in the areas deemed most representative of the problem involved. In every case evalua-

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tions were conducted with the cooperation of a commercial grower. Insecticides were applied by research equipment, except in certain instances when the grower applied the materials under supervision. All chemicals were tried at dosages and intervals with practical limitations designed for eventual recommendation.

The following insecticides and acaricides were evaluated: Chlorobenzilate (ethyl 4, 4-dichlorobenzilate), Delnav (2, 3-p-dioxanedithiol S, S-bis-0, 0 diethyl phosphorodithioate), Diazinon (0, 0-diethyl 0-2-isopropyl-6 methyl-4-pyrimidyl thiophosphate), Genite (2, 4-dichlorophenyl benzenesulfonate), Guthion (0, 0-dimethyl S-4-oxo-3H-1, 2, 3-benzotriazine-3-methyl-phosphorodithioate), Kelthane (1, 1-bis p-chlorophenyl -2, 2, 2-trichloroethanol), Mitox (p-chlorobenzyl p-chlorophenyl sulfide), Nialate (bis-S-diethoxyphos-phinothioyl mercaptomethane), Phosdrin (2-methoxycarbonyl-1-methylvinyl dimethyl phosphate), Sevin (N-methyl-1-naphthyl carbamate), Tedion (p-chlorophenyl 2, 4, 5-trichlorophenyl sulfone), Tetram 75 (0, 0 diethyl S-beta-diethylamino ethyl phosphorothiolate hydrogen oxalate), Thimet (0, 0-diethyl S-ethylthiomethyl phosphorodithioate), Trithion (S-p-chlorophenylthiomethyl 0, 0-diethyl phosphorodithioate), 1189 (decachlorotetrahydro-4, 7-methanoindenone), and 12008 (0, 0-diethyl S-isopropylthiomethyl phosphorodithioate).

RESULTS AND DISCUSSION

Mites

European red mites have plagued fruit growers in the past decade, primarily because of their resistance. As a result numerous compounds have been marketed for the control of this pest. Table 1, adapted from research data, indicates the ability of certain chemicals as specific miticides.

Table 1 shows that several choices may be available in the future. Although there are few significant differences in performance data between most of the compounds, certain conclusions can be made. For example, the best control in experimental mite blocks of apples was obtained by the use of a combination of an early miticide (pink period) and mid-summer applications of phosphate and non-phosphate materials on an alternating basis. Parathion-resistant red mites were satisfactorily controlled by this method.

Two-spotted mites have been troublesome on apples, strawberries, brambles, and currants. In Table 2 data of two-spotted mite control on currants are given.

TABLE 1—Various miticides, best period of application, and expected residual life

Material	Suggested application time	Approximate residual life
Aramite	any time	10-15 days
Chlorobenzilate	any time	10-15 days
Delnav (*a*)	mid-summer	20-30 days
Genite	pre-pink, pink	4-6 weeks
Kelthane	mid-summer	3 weeks
Mitox	pink, early covers	4-6 weeks
Ovex	pink, 2 early covers	6 weeks
Systox (*a*)	early covers	1-3 weeks
Tedion	any time	5 weeks
Tetram 75 (*a*)	early covers	7 weeks
Trithion (*a*)	pre-pink, early covers.	6 weeks
Thimet (*a*)	early covers	3 weeks

(*a*) Effective against aphids.

TABLE 2—Control of two-spotted mite on currants, Eau Claire, Michigan, 1957

Material	Formulation	Amount of actual insecticide per 100 gal.	Number of applications	Percent difference in favor of treatment (*a*)
Kelthane	18 EC (*b*)	4.6 oz.	2	98
Systox	26 EC	3.0 oz.	2	90
Tetram 75	75 WP (*c*)	1.5 oz.	3	96
Ovex	50 WP	4.0 oz.	3	94
Parathion	15 WP	3.6 oz.	4	97
Aramite	15 WP	3.6 oz.	3	96

(*a*) Calculated from Abbott's formula:

$$\frac{\text{No. of live forms in untreated block} - \text{No. of live forms in treated block}}{\text{No. of live forms in untreated block}} \times 100$$

(*b*) Emulsifiable concentrate.
(*c*) Wettable powder.

There is substantial evidence that the phosphate miticides are not as effective as the non-phosphate type for controlling two-spotted mites. Repeated parathion sprays will contain this species of mite, but usually won't completely control it. In this experiment Kelthane was the most efficient compound evaluated since control by two applications was significantly different than results from three sprays of Aramite or Ovex.

Codling Moth

In 1957 the worst outbreak of codling moth since the pre-DDT era occurred in southwestern Michigan. Many apple growers suffered economic loss despite conventional spray programs. In the experimental plots at Paw Paw, three new insecticides were compared with the currently recommended schedule (Table 3).

TABLE 3—Control of codling moth in apples, Paw Paw, Michigan, 1957 (a)

Material	Formulation	Amount of actual insecticide per 100 gal.	Total number injured fruits at harvest per 5,000	Mean number injured fruits per plot	Percent difference in favor of treatment
Standard...	(a)	(b)	718	144	50.2
Diazinon...	25 WP	8 oz.	227	46	84.9
Diazinon...	25 WP	4 oz.	491	98	71.1
DDT.....	50 WP	8 oz.			
Guthion....	15 WP	8 oz.	22	4	97.7
Sevin.....	50 WP	8 oz.	101	20	92.8
Check.....	.....	....	1,331	266	....
			LSD 5 percent=15.7		
			1 percent=21.5		

(a) Sprays applied at 2-week intervals except for standard which was applied at 10-day intervals.
(b) DDT plus parathion at conventional dosages.

In this particular trial, it was suspected that codling moth was partially resistant to DDT. Apparently, the problem has been increasing in this orchard for the past two seasons.

The data indicate that the three individual compounds are superior to the standard, and that Guthion and Sevin are outstanding. Analysis of variance of data from this experiment indicated no significant variation within replicates of the treatments. Consequently, the data presented represents a true picture of the biological performance of the insecticides involved. Diazinon results substantiate data from 1956 and this insecticide will be recommended with certain reservations in 1958.

Guthion is a very promising material. It has a wide range of insecticidal ability with good persistence. Although a phosphate in nature, Guthion does not contain the phytotoxic properties that are present in other phosphate compounds. It is similar to parathion in toxicity to humans, but if handled properly, the chemical is safe for

commercial usage. Guthion apparently kills both the adult and larval forms of codling moth.

Sevin is another excellent insecticide with a broad spectrum. It is neither chlorinated-hydrocarbon nor phosphate, yet it has produced excellent control of several insect pests. Chief advantages of Sevin will be low mammalian toxicity and versatility. However, Sevin will not control mite populations.

Red-Banded Leaf Roller

This insect has become one of Michigan's worst fruit pests. Each season there are three broods which attack a wide range of host plants. Leaf rollers have shown a partial tolerance to the specific insecticide, DDD, and in parts of Michigan much damage to fruit occurred in 1957. Table 4 presents data on experimental plots established for the control of the red-banded leaf roller.

TABLE 4—Control of red-banded leaf roller on apples, Spinks Corners, Michigan, 1957 (a)

Material	Formulation	Amount of actual insecticide per 100 gal.	Total number injured fruits at harvest per 250	Mean number injured fruits per plot
Thimet	48 EC	1 lb.	21	4
12008	48 EC	1 lb.	21	4
Guthion	15 WP	8 oz.	5	1
Phosdrin	2 EC	8 oz.	7	1
Sevin	50 WP	1 lb.	11	2
Trithion	25 WP	12 oz.	79	16
Nialate	25 WP	8 oz.	44	9
DDD	50 WP	1 lb.	25	5
Check	.....	....	134	27

LSD 5 percent = 1.7
1 percent = 2.3

(a) Sprays applied at 14-day intervals all season starting at petal fall.

In this experiment, three new compounds produced significantly better control of red-banded leaf rollers than the standard material. As in the codling moth trial, Guthion and Sevin demonstrated excellent insecticidal activity. From the standpoint of versatility both chemicals appear very promising. Phosdrin, a unique phosphate insecticide which decomposes very rapidly, also gave fine control of this pest.

Variance analysis within replicates indicated significant variation at the 1 percent level. This was probably due to varietal selection by leaf rollers since the experiment was conducted with three varieties of apples. A greater infestation of leaf rollers existed on Jonathan trees and this could account for the significant variation within replicates. However, the variation was not of sufficient magnitude to cause unreliability among the raw data.

Two other phosphate insecticides, Thimet and 12008, were not significantly different from the standard, but certain physical properties of these compounds may make them undesirable as foliar sprays. Nialate should not be completely ruled out as the dosage or interval factors may have affected the performance of the material in this particular experiment. Repeated applications of Trithion created phytotoxicity problems especially with Jonathans; therefore, its scope will be limited.

Oriental Fruit Moth

The oriental fruit moth is probably the most feared insect that attacks peaches as most of the damage usually occurs near the harvest period. Research with new insecticides has produced some interesting and encouraging data and the results are presented in Table 5.

TABLE 5—Control of oriental fruit moth in peaches, St. Joseph, Michigan, 1957 (a)

Material	Formulation	Amount of actual insecticide per 100 gal.	Total number injured fruits at harvest per 400	Mean number injured fruits per plot
Thimet	48 EC	1 lb.	57	14
Guthion	15 WP	8 oz.	5	1
12008	48 EC	1 lb.	95	24
Sevin	50 WP	8 oz.	116	29
Trithion	25 WP	8 oz.	99	25
Parathion	15 WP	3.6 oz.	51	13
DDT	50 WP	1 lb.	63	16
DDT	50 WP	8 oz.	42	10
Parathion	15 WP	3.6 oz.		
Check	.....	....	494	123

LSD 5 percent = 7.2
1 percent = 9.8

(a) Treatments applied at 2-week intervals all season starting at petal fall.

At present, the standard recommendations of DDT and/or parathion have satisfactorily contained the oriental moth. Good control has been obtained by weekly applications of the combination of DDT and parathion; but, obviously this necessitates considerable spraying. Performance of Guthion is highly encouraging since it gave the best control of all chemicals evaluated and fewer applications were required. Results with Sevin undoubtedly could be improved if the dosage were increased and interval of application decreased. Observations made during the course of this experiment indicate that phosphate compounds are most effective against fruit moth eggs and newly hatched larvae.

Strawberry Insect Experiments

Several insects are economic pests to strawberry growers. Among these are various species of leaf rollers and spittlebugs. Research work conducted in five counties in the past two seasons has shown promise toward suggesting a group of chemical choices for the control of both pests (Table 6).

TABLE 6—Spittlebug and leaf roller control on strawberries, 1956 and 1957 (a)

Material	Formulation	Amount of actual insecticide per 100 gal.	Percent difference in favor of treatment			
			Spittlebug		Leaf-rollers	
			1956	1957	1956	1957
BHC	25 WP	4 oz.(b)	100	100	0	0
Dieldrin	50 WP	2 oz.	98	99	0	0
Dieldrin	50 WP	4 oz.	100	100	0	0
Dieldrin	50 WP	8 oz.	100	100	0	0
Parathion	15 WP	4.8 oz.	78	85	77	73
Methoxychlor	25 EC	1 lb.	93	90	10	14
Heptachlor	25 EC	1 lb.	100	99	0	0
Thimet	48 EC	1 lb.	95	99	95	77
12008	48 EC	1 lb.	97	99	97	75
Guthion	18 EC	8 oz.	97	99	84	99
Sevin	50 WP	8 oz.	..	99	..	90
Trithion	4 F(c)	8 oz.	..	100	..	84
1189	50 WP	8 oz.	..	99	..	100
Nialate	25 WP	8 oz.	..	100	..	99
Diazinon	25 WP	8 oz.	99	99	69	87
Delnav	25 WP	1 lb.	94	..	16	..
DDD	50 WP	1 lb.	0	0	96	98

(a) Applied as foliar sprays in one application pre-bloom; counts made at harvest.
(b) Gamma isomer.
(c) A water soluble suspension containing 4 pounds actual insecticide per gallon.

An attempt was made through this particular research series to locate one or more compounds which could singly control both spittlebugs and leaf rollers with only one application. Nialate, 1189, and Trithion along with Guthion, Sevin, and Thimet all did this. Pre-bloom applications are more desirable than sprays after fruit has set because certain chemicals are greatly persistent which creates residue problems.

At least four species of leaf rollers have been collected from strawberry plantings in the two seasons of experimentation. Most common are the strawberry leaf roller (*Ancylis comptana*) and oblique-banded leaf roller (*Archips rosaceana*). Of lesser importance, but nevertheless present, are the obsolete-banded leaf roller (*Archips obsoletana*) and the red-banded leaf roller (*Eulia velutinana*). There are usually three broods of the common leaf roller and one to two broods of the oblique-banded. The other species are relatively incidental and do not present special control problems.

In nearly every incidence of egg-laying by any species of leaf rollers, the eggs are deposited on the underside of the leaves. This factor makes control difficult unless thorough spraying is performed.

The meadow spittlebug (*Philaneus leucophthalmus*) has but one generation per season. When present in large numbers, this insect can cause a marked reduction in yield and harvesting becomes objectionable from the presense of numerous spittle masses. Dieldrin has performed significantly better control of spittlebugs than standard recommended chemicals. If dieldrin is applied pre-bloom, no residue problem would exist. A combination of DDD and dieldrin would be an excellent spray for an infestation of both leaf rollers and spittlebugs in strawberries.

SUMMARY

Several new insecticides and miticides have been evaluated for biological activity against important fruit insects during the past two seasons as a part of the Fruit Insect Research program in the department of entomology. The work can be briefly summarized as follows:

1. New miticides which are non-phosphate materials that show good promise are Genite, Mitox, Tedion, Kelthane, and Chlorobenzilate. The former two are especially effective against red mite populations when applied in the pre-bloom stage on apples. All but Genite can be used as post-bloom sprays. New phosphate-type acaricides are Delnav, Tetram 75, Trithion, and

Thimet. These do not show much potential with phosphate-resistant mites, but when used in alternate schedules with non-phosphate chemicals they are similarly effective.

2. Two-spotted mites have been more easily controlled with non-phosphate chemicals than with the phosphate variety.
3. Guthion, Sevin, and Diazinon have given better results on codling moth control than standard recommended materials.
4. Guthion and Sevin are excellent insecticides for red-banded leaf roller. Phosdrin, a rapidly decomposing phosphate compound, is a very effective insecticide for pre-harvest needs, especially against leaf rollers.
5. The best standard control measure for oriental fruit moth in peaches is the combination of DDT and parathion. Guthion is outstanding for controlling this pest.
6. Dieldrin performed excellently as an insecticide for spittlebugs on strawberries. A combination of DDD and dieldrin prevents spittlebug and leaf roller build-up when applied as a pre-bloom spray. New chemicals which contain both insects satisfactorily with one application are Nialate, Guthion, and 1189.

FERTILIZER PLACEMENT STUDIES WITH THE PICKLING CUCUMBER

By W. W. McCALL, R. E. LUCAS, C. M. HANSEN[1] *and W. C. HULBURT*[2, 3]

MICHIGAN RANKS FIRST in the United States in total production of pickling cucumbers. The annual production amounts to 3,500,000 bushels on 35,000 acres. Fertilizer practices vary considerably for this crop particularly with regard to the placement of fertilizer in relationship to the seed.

The effect of fertilizer placement on cucumbers has recently been investigated in Michigan by Wittwer and Tyson[4], McCall and Ries[5], and Miller.[6] Work has been partly limited by the lack of precision equipment for the placement of fertilizer during the planting operation.

The agricultural engineering department of Michigan State University and the Agricultural Research Service of the United States Department of Agriculture, in cooperation with the soil science department, established a project early in 1956 to include designing and constructing an experimental planter which would give the desired placement.

DESCRIPTION OF EQUIPMENT

The equipment developed (Fig. 1) includes top delivery fertilizer hoppers, two-plate vegetable planters with double disc soil furrow openers for seed, and two rolling coulter furrow openers for fertilizer with each seed unit. This special vegetable drill for mineral soils has been designated as FJ 69 Drill of the cooperating federal unit.

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[3] Acknowledgment is given of the assistance of R. F. Dudley, D. B. Eldredge and Robert Wilkinson in the design and construction of the machine in the laboratory of the Agricultural Engineering Department at East Lansing. These men are respectively, Research Agricultural Engineer and Engineering Aide, of the above section at Beltsville, and instructor in Agricultural Engineering at M.S.U.
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[6] Miller, C. H. (1957). Studies of the nutrition and physiology of pickling cucumbers. Thesis for degree of Ph.D., Mich. State Univ.

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Fig. 1. The new fertilizer placement equipment designed especially for experimental work with vegetable crops on mineral soils. This machine was used for planting the cucumber seed and placing the fertilizer in 1957.

The rolling coulter furrow openers used on this machine were developed by Michigan State University for an experimental corn planter and were described by Hansen and Lucas[7] as follows:

"A furrow opener was mounted on each side of an 18-inch diameter rolling coulter. Each opener was forged in saber-like fashion from carbon steel. The leading edge of each furrow opener cleared the rolling coulter by $\frac{1}{16}$ inch and had a radius 2 feet in a plane parallel to the coulter.

"Cold rolled steel strips were welded to the training edge of the furrow openers making a fertilizer passageway. One opener was adjusted to place a band of fertilizer 2 inches to the side and 2 inches below the seed, while the other opener placed the band 4 inches lower than the upper band. This deeper fertilizer band was placed near the limit of penetration of the 18-inch coulter."

Two of these devices are used with each seed unit as shown in Fig. 2. The second coulter has only one saber and it places the fertilizer near the limit of penetration of the 18-inch diameter coulter.

The metering mechanism of the fertilizer hoppers is driven by the

[7] Hansen, C. M. and R. E. Lucas (1954). A rolling coulter furrow opener for deep placement of fertilizer. Mich. Agr. Expt. Sta. Quart. Bul. 36: 310-317.

power take-off of the tractor (Fig. 3). This is a rather unique feature since most fertilizer distributor metering mechanisms are driven from a ground wheel.

The tractor which was used for this machine had provisions for shifting the power take-off to a "ground-drive" position which facilitated the operation of the fertilizer hoppers only when the tractor moved irrespective of the foot-clutch position. The worm gear reduction unit, mounted on the power take-off, has a 40-1 ratio and can be operated in standard power take-off if so desired.

The use of the standard power take-off gear assured accurate fertilizer delivery at the beginning of the experimental plot by eliminating the lag in the driving mechanism. This lag is a common fault with ground drive fertilizer metering mechanisms. It is caused by slack in chains, gears, and drive wheel. The fertilizer rate can be adjusted from 20 to 1,000 lb. per acre.

Fig. 2. Two rolling coulters with furrow openers are used with each planting unit. These coulters made it possible to place the fertilizer in a band 2 inches to the side and 2 inches below the seed and or in a band 2 inches to the side and 6 inches below the seed.

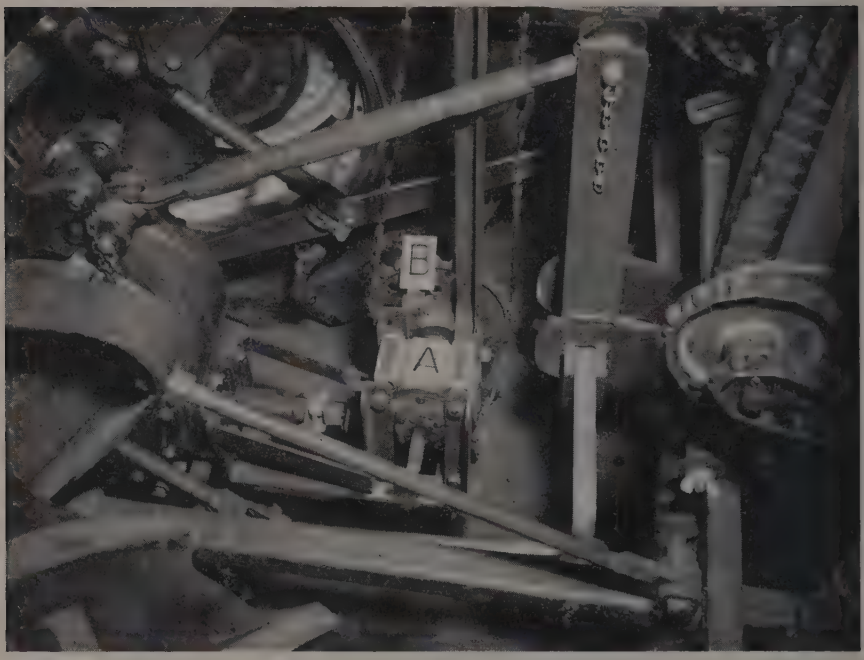

Fig. 3. The power take-off drive for the metering mechanism of the fertilizer hoppers. "A" is the worm reduction gear with a ratio of 40-1 and "B" is the drive wheel which furnishes power to the metering mechanism. By changing the size of the drive wheel, "B", the fertilizer rate may be varied from 20 to 1,000 lb. per acre.

Row spacing is easily adjusted throughout the width of the tool bar and the fertilizer placement, with respect to the seed, and can be changed to any desired experimental position. A screw adjustment functioning diagonally across the parallelogram controls the depth of fertilizer. A series of holes was drilled in the plate (Fig. 4) in front of the rubber tired press wheel to control the horizontal placement, with respect to the seed.

EXPERIMENTAL PROCEDURE

A commercially produced planter (Fig. 5) was used in field experiments initiated in 1956, to study the effect of the placement of fertilizer on the growth and yield of pickling cucumbers. This equipment was not satisfactory because of the difficulty encountered in making adjustments.

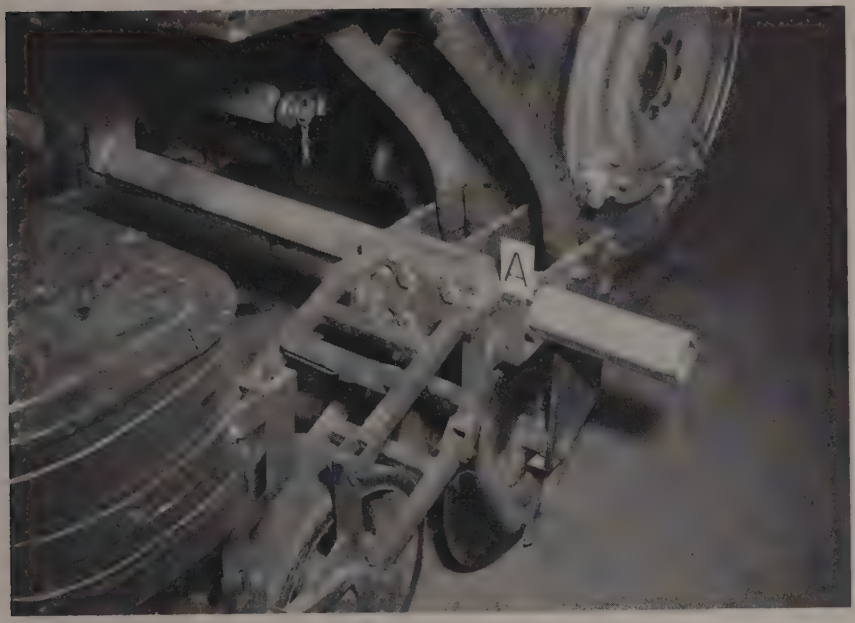

Fig. 4. The horizontal placement of the fertilizer with respect to the seed may be controlled by moving the plate "A" from one position to another by use of the holes drilled in this plate.

Fig. 5. The commercial planter used in 1956 for placing the fertilizer. This planter does not have the range of fertilizer adjustments nor the ease of adjustment of the experimental placement equipment.

The experiment was conducted on Conover loam of moderately low fertility (15 lb. of phosphorus per acre and 110 lb. of potassium per acre as extracted with 0.13N HCl). A heavy cover crop of rye was plowed down about 1 week before planting.

A 12-12-12 analysis fertilizer was placed at the rate of 300 lb. per acre in 1956 and 420 lb. per acre in 1957. The Ohio MR-17 variety was planted June 9, 1956 and the Wisconsin SMR 12-12 on the same date in 1957. The plots consisted of two rows, 5 feet apart, and 35 feet long. The treatments, described in Table 1, were replicated three times.

TABLE 1—The effect of fertilizer placement upon the yield of pickling cucumbers (a)

Treatments	Yields per acre, cwts.		Average
	1956	1957	
1. No fertilizer	18	85	52
2. Broadcast	30	125	78
3. N. Broadcast, P and K 2″ side 2″ below seed	66	202	134
4. P Broadcast, N and K 2″ side 2″ below seed	34	178	106
5. K Broadcast, N and P 2″ side 2″ below seed	47	172	110
6. All fertilizer 2″ side 2″ below seed	39	133	86
7. All fertilizer 2″ side 6″ below seed	43	155	99
8. ½ fertilizer 2″ side 2″ below seed ½ fertilizer 2″ side 6″ below seed	45	157	101
9. All fertilizer 2″ below seed	43	147	95
10. ½ fertilizer broacast ½ fertilizer 2″ side 2″ below seed	47	167	107
L.S.D. 5 percent level	19	45	32
L.S.D. 1 percent level	26	62	44

(a) 12-12-12 fertilizer, 300 pounds per acre in 1956 and 420 pounds in 1957. Variety—Ohio MR-17 in 1956, Wisconsin SMR—12-12 in 1957.

The fertilizer band was about 1 inch wide. The measurements refer to the horizontal and vertical distances between the seed and fertilizer, or the measurement of free soil between the two.

The experiment was planned so that each treatment was repeated on the same plot each year. This method insures that the residual effects of the previous fertilizer applications, if any, are confined to the same plot.

Plants were thinned to approximately one plant per 12 inches. Sprays for insect and disease control were applied when necessary. Weeding was done both mechanically and by hand. The cucumber

fruits were harvested semi-weekly during the months of August and September until nine or ten pickings had been made.

RESULTS AND DISCUSSION

Observations made early in July indicated the plants had a better start where all or part of the fertilizer had been broadcast.

Placing the fertilizer in a band 2 inches to the side and 6 inches below the seed seemed to be a poor method because the plants grew slowly and were pale green in color.

Germination was affected where the fertilizer was placed 2 inches below the seed; in July the plants were irregular in size and color. However, the final yield results did not bear out these early observations. Both of these treatments produced good yields even though they made a poor start. These differences may be accounted for in fertilizer recovery, salt concentration, and the time lapse before the roots reached the fertilizer.

Plots receiving an application of fertilizer produced higher yields than those not receiving fertilizer. In some cases, as shown in Table 1, the increases in yield were three-fold.

The yields in 1957 were higher than in 1956 for all methods of application due, in part, to the use of a higher yielding variety and of more fertilizer. The effect of residual fertilizer and differences in weather conditions were also partly responsible. However, the differences in yield follow the same approximate order and magnitude except in one instance.

In 1957, all treatments were significantly better than the no fertilizer treatment although where the fertilizer was broadcast, the treatment wasn't quite as successful. This agrees with the work of Wittwer and Tyson[8] and Miller[9] who found this crop highly responsive to the use of fertilizer.

In 1957, all other treatments were statistically significant at the 1-percent level over the check treatment except where the fertilizer had been placed in a band 2 inches to the side and 2 inches below the seed. In 1956, only three treatments were significantly better at the 1-percent level than the check treatment.

Highest yields in both years were obtained from plots where the nitrogen was broadcast and the phosphorus and potassium placed in a band 2 inches to the side and 2 inches below the seed. This method of placement was significantly better than all other treatments except

[8] Op. Cit.
[9] Op. cit.

where part of the fertilizer was broadcast. The high yield may be due to a lower concentration of salt.

When part of the fertilizer was placed in a band 2 inches to the side and 2 inches below the seed and part in a band 2 inches to the side and 6 inches below the seed, the plots produced higher yields than did the placement of all the fertilizer in either band or all of the fertilizer in a band 2 inches below the seed. While these differences were in favor of the split-side placement, the differences were not statistically significant.

Plots where one-half of the fertilizer was broadcast and one-half was placed in a band 2 inches to the side and 2 inches below the seed produced the highest yields of any plot where the so-called "standard" methods of placement were employed. This method is easy to follow with existing equipment for the application of fertilizers. It produced higher yields than any method except broadcasting the nitrogen and applying the phosphorus and potassium in the row, in 1956; and was one of the highest producing methods in 1957.

When all of the fertilizer is placed in one band in 5-foot-row spacing, it causes a relatively high concentration of soluble salts. When the band is near the seed, as it is when it is placed 2 inches to the side and 2 inches below or just 2 inches below it, this relatively high salt concentration may cause injury and reduce yields. Thus, placing the fertilizer deeper or splitting it into two bands or into one band-part broadcast would decrease salt concentration near the seed. The data show that there was some increase in yields where this was done. However, when all of the fertilizer was broadcast, yields were reduced because of the decreased availability of phosphorus and potassium in the soil.

SUMMARY

The development of new equipment for fertilizer placement made possible more accurate placement studies with vegetable crops.

Fertilizer placement studies with pickling cucumbers were conducted on Conover loam in 1956 and 1957. A 12-12-12 fertilizer was applied at the rate of 300 lb. per acre in 1956 and 420 lb. per acre in 1957.

Plots which produced the greatest yields were those on which the nitrogen was broadcast and the phosphorus and potassium were placed in a band 2 inches to the side and 2 inches below the seed. The average yield was 134 hundred weights per acre for the 2 years.

Lowest yields, 78 hundred weights per acre, were obtained from plots broadcast with fertilizer after they had been plowed.

When one-half of the fertilizer was broadcast and the other half was placed in a band 2 inches to the side and 2 inches below the seed, the plot produced an average of 107 hundred weights per acre.

Maximum yields were obtained by broadcasting the plant nutrient (nitrogen) carrier which causes the greatest salt content in the soil. This work would indicate that more information on salt concentration in fertilizer applications might point the way to greater yields of crop plants.

CHERRY LEAF SPOT CONTROL AND PHYSIOLOGICAL EFFECTS BY NEW AND STANDARD FUNGICIDES[1]

By E. J. KLOS and E. REBMAM[2]

CHERRY LEAF SPOT FUNGUS, *Coccomyces hiemalis*, is the cause of our most serious fungal disease of Montmorency cherry in Michigan. It is found in orchards every year in varying degrees of severity. Early defoliation caused by this disease organism reduces fruit set for the following year and predisposes the tree to winter injury.

The purpose of this study was to test several new fungicides against a number of standard recommended chemicals in the control of this disease. All compounds were also tested for their effect on total solids of mature fruit and possible lead arsenate safening.

METHODS

A protective spray program was used in this test (Table 1). The first spray was applied at three-fourths petal fall followed by four

TABLE 1—Chemicals and rates used in cherry leaf spot treatments

Fungicide	Rate per 100 gallons of spray	Source
Niacide Z-65	2 pounds	Niagara Chemical Division
Cyprex	1 pound	American Cyanamid Co.
Phygon	1 pound	United States Rubber Co.
Thylate	1½ pounds	E. I. DuPont deNemours and Co., Inc.
Glyodin	1 quart	Carbide & Carbon Chemical Co.
Captan	2 pounds	California Spray-Chemical Corp.
Phybam S	4 pounds	Pittsburgh Plate Glass Co.
Actidione	1 part per million.	The Upjohn Co.

cover sprays at 10 or 11 day intervals. The sprays were thoroughly applied with a hand gun at a pressure of 500 pounds per square inch.

[1] The authors wish to acknowledge assistance and cooperation of Mr. B. Lumley of Boyne City, Michigan. Helpful assistance in statistical analysis was obtained from Drs. S. Ries and J. Downes of the horticulture department.

[2] Extension specialist in plant pathology, agricultural agent, Charlevoix County.

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No safener was added to the lead arsenate plus fungicide combination in order to study the safening potentialities of the different fungicides. The checks received lead arsenate in the last three cover sprays and on July 6.

Leaf spot and lead injury counts were made on July 18. Ten leaves from 10 terminals picked at random were checked for leaf spot and lead injury from each tree. There were three replicated plots of three trees each with the exception of Actidione, Phygon, Thylate, Glyodin, Captan, and Phybam S which had two trees in the third replicate. The checks had one tree in each replicate.

TABLE 2—Active ingredients of the fungicides tested

Fungicide	Active ingredients
Niacide Z-65	zinc dimethyl dithiocarbamate+zinc benzothiazylmercaptide
Cyprex	n-dodecylquanidine acetate
Glyodin	2-heptodecyl glyoxalidine acetate
Thylate	Tetramethylthiuramdisulfide
Actidione	B /2-(3,5-dimethyl-2-oxocyclohexyl)-2-hydroxyethyl glutarimide
Phygon	2,3-dichloro-1,4-naphthoquinone
Captan	N-trichloromethylmercapto-4-cyclohexene-1,2-dicarboximide
Phybam S	2,3-Dichloro-1,4-Napththoquinone+Ferric dimethyldithiocarbamate+sulfur

The total solids were taken with a Bausch and Lomb refractometer on July 19 about 4 days before harvest.

On October 9, leaf drop counts were made by counting leaf scars at the buds from 10 terminals picked at random from each tree.

The following lists the application dates and rainfall.[3]

May 13— .21 inch
14— .53 inch
15— .76 inch
16— .02 inch
17—Niacide Z-65 (½ petal fall)
18— .07 inch
20—Balance of first spray applied (¾ petal fall)
22—1.38 inches
23—Trace
24— .13 inch
26— .42 inch
27— .04 inch
29—Trace
30— .06 inch
31— .07 inch
31—Second spray plus 3 pounds lead arsenate
June 1— .14 inch
6— .03 inch
7— .40 inch
10—Third spray + 2 inches lead arsenate

[3] Rainfall data received from the Conservation Department, Boyne City.

11— .05 inch
12— .67 inch
June 13— .63 inch
14—1.03 inches
15—Trace
16— .04 inch
17— .05 inch
18— .17 inch
20—Fourth spray + 2 pounds lead arsenate
25— .86 inch
26— .07 inch
27—1.12 inches
28— .03 inch
29—1.43 inches

July 4— .25 inch
5— .23 inch
6—Lead Arsenate, 2 pounds alone on all trees
8— .61 inch
11— .05 inch
13— .48 inch
18—Counts made. All trees sprayed with Actidione, 2 p.p.m.
22— .06 inch
Aug. —1.92 inches total rainfall
Sept. —3.47 inches total rainfall
Oct. 9—Final leaf spot counts

RESULTS

Counts on July 18 (Table 3), show that all of the fungicides in the test gave highly significant reductions in leaf spot. However, Captan, Phybam S, and particularly Niacide Z-65 were not as outstanding in leaf spot control as Cyprex, Actidione, Phygon, Thylate, and Glyodin.

No evaluation of lead injury was made for the checks because the heavy leaf spot infection obscured the lead injury symptom. The Captan treatment can be used as a standard since it is recommended

TABLE 3—Comparison of various fungicides in the control of cherry leaf spot.

Treatment	Infected leaves (mean)
Cyprex 1 lb.-100	.9
Actidione 1 p.p.m.	1.9
Phygon 1 lb.-100	2.0
Thylate 1½ lb.-100	2.2
Glyodin 1 qt.-100	2.6
Captan 2 lb.-100	5.1
Phybam S 4 lb.-100	9.1
Niacide Z-65 2 lb.-100	15.2
Check (no fungicide)	61 3
L.S.D.—.01	38.6

as a lead safener. Niacide and Actidione showed significant and highly significant differences respectively to the standard Captan (Table 4). Note that Thylate and Glyodin were just significantly different to Captan.

TABLE 4—Lead injury observed in the various fungicide treatments

Treatment	Injured leaves (mean)
Captan	1.3
Phygon	2.4
Cyprex	3.7
Phybam S	3.9
Thylate	5.0
Glyodin	5.4
Niacide	6.7
Actidione	15.8
Check (no fungicide)	....(a)
L.S.D.—.05	5.0
L.S.D.—.01	7.0

(a) Too heavily infected with leaf spot to determine lead injury.

Total number of solids is used by most processors as one of the quality criteria for cherries. In Table 5, the fungicides that gave the least leaf spot control had readings equal to the check or higher. Thylate, Phygon, Glyodin, and Actidione gave significantly lower

TABLE 5—Effect of chemical sprays on total solids of mature fruit

Treatments	Total solids (mean)
Captan	14.3
Phybam S	14.2
Check (no fungicide)	14.0
Niacide	14.0
Cyprex	13.8
Glyodin	12.9
Thylate	12.8
Phygon	12.8
Actidione	12.2
L.S.D.—.05	.5

total solids readings than the check. Cyprex was approximately equal to the check.

On July 18, after leaf counts were made and samples taken for soluble solids evaluations, all the plots were sprayed by the grower with Actidione at 2 p.p.m. On October 9 it was observed that certain plots had more defoliation as a result of leaf spot than others. A count was made from each tree for leaf drop, a result of leaf spot infection.

The Cyprex treatment was the most outstanding of all treatments with only a mean leaf drop of 5.4 leaves (Table 6). Cyprex, Glyodin, Thylate, and Rhygon had significantly more leaves than the check. Captan was just significant.

Phybam S and Niacide were comparable to the checks at this count.

TABLE 6—Leaf drop, a result of cherry leaf spot infection in the various treatments

Treatment	Leaf drop (mean)
Cyprex	5.4
Glyodin	37.4
Thylate	45.3
Phygon	46.4
Captan	61.4
Actidione	72.0
Phybam S	84.4
Niacide	85.4
Check (no fungicide)	86.3
L.S.D.—.05	21.6
L.S.D.—.01	29.7

DISCUSSION

The high leaf spot count on the checks on July 18 indicates high inoculum in the orchard. The rainfall data points out ideal conditions for disease development. Most of the chemicals gave good control at this time. Phybam S control was not as good as the others probably because of insufficient amounts of Phygon and Ferbam and probable poor weathering of Ferbam. Poor weathering could also account for Captan's rating. This has been shown in weathering studies on apples by Szkolnik and Hamilton.[4]

[4] Szkolnik, M. and J. M. Hamilton (1957). Performance of new materials as protectants in greenhouse and orchard evaluation. Pl. Dis. Rpt. 41:296.

Captan, a recognized lead safener, was rated the best in our test. Two of the more promising materials, Phygon and Cyprex, showed lead safening potentialities. Since most growers in Michigan use lead arsenate for maggot control, this safening property is an asset to a fungicide. Thylate and Glyodin are just significant. In Michigan, a safener is recommended for Actidione and Glyodin sprays because of a past lead injury history.

Since this is one of the first reports on Thylate and Phygon with respect to lead injury on cherries, further studies will have to be carried out in the future. Although a lead spray was applied alone on July 6 there were still significant differences on July 18 in many of the treatments.

Cyprex, Thylate, Phygon, Glyodin, and Actidione gave lower readings than the check in total solids. All these chemicals gave better control of leaf spot than the materials that were equal or better than the control in total solids readings. Thylate, Rhygon, Glyodin, and Actidione gave significantly lower readings while Cyprex did not.

On July 18, an Actidione spray of 2 p.p.m. was applied to all the plots and no other spray was applied for the rest of the season. If an additional spray was applied after harvest, the picture would have been different. Without this spray, the October 9 counts indicate the possible prolonged protective action of the various fungicides.

With the exception of Actidione, the chemicals that gave control on July 18 ranked the highest in the final control. Actidione breaks down rapidly which could account for the leaf spot build up late in the season.

The outstanding result is with Cyprex. Out of a possible 900 leaves, a total of 852 remained on the tree. Most of the remaining foliage had little or no leaf spot infection at this time. These data suggest a systemic action of the compound as reported by Hamilton.[5]

Similar results with Cyprex control of cherry leaf spot were obtained by Cation in 1957.[6]

SUMMARY

Cyprex was outstanding in cherry leaf spot control. It safened against lead injury and the total solids readings of Cyprex sprayed fruit were comparable to the check at harvest. This spray gave long protection suggesting systemic action.

[5] Hamilton, J. M. (1957). Report given at N. Y. insecticide fungicide meeting, Cornell Univ. (Unpublished)

[6] Cation, D. (1957). Two years' results of testing cyprex for control of cherry leaf spot in Michigan. Pl. Dis. Rpt. 441, 1029.

Phygon and Thylate gave good results in leaf spot control. Phygon was superior to Thylate in lead safening and both sprays gave low total solids readings.

The Actidione plots were heavily infected late in the season. This spray was poor as a lead safener and the total solids readings were very low.

Captan plots fell down late in the season. However, this treatment had little lead injury and gave the highest total solids readings.

Glyodin gave moderate control and total solids readings. The lead safening was rated low.

Phybam S and Niacide Z-65 gave only fair control early in the season and poor control by late summer. Phybam S gave better lead safening than Niacide. Both materials had total solids readings comparable to the check.

BACTERIAL SPOT OF PEACH AND ITS CONTROL[1]

By E. J. KLOS
DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

GENERALLY, BACTERIAL SPOT of peach is a yearly problem in only a few orchards in Michigan. However, in 1955 this disease organism became widespread particularly in the southwestern part of the state. It not only infected the foliage, but also the fruit. This resulted in reduced quality and lower prices.

Symptoms

One of the problems is to recognize the disease in its early stages. The characteristic early leaf symptoms are the angular dead spots. In the advanced stages the spots concentrate at the tip of the leaf. This is because the rains and dews wash the bacteria toward the tip. Finally, the entire infected leaf turns yellow and falls to the ground (Fig 1).

The early fruit symptom is a small brown sunken spot usually found on the exposed side (Fig. 1). Cracking or pitting occurs near the spot as a result of natural fruit enlargement. Coalescing of these areas results in a large lesion. Some varieties exude gum at the spot. Fruit symptoms are common when early season infections take place.

Varietal Susceptibility

Some of the major Michigan varieties that are most susceptible to the disease organism are Hale, Hale Haven, Elberta, Kalhaven, and Sunhigh.

Life Cycle

The bacteria overwinter in inconspicuous cankers and possibly terminal buds. At petal fall, the bacteria are spread by wind and rain to young foliage and later to other leaves, tender twigs, and

[1] A preliminary report.

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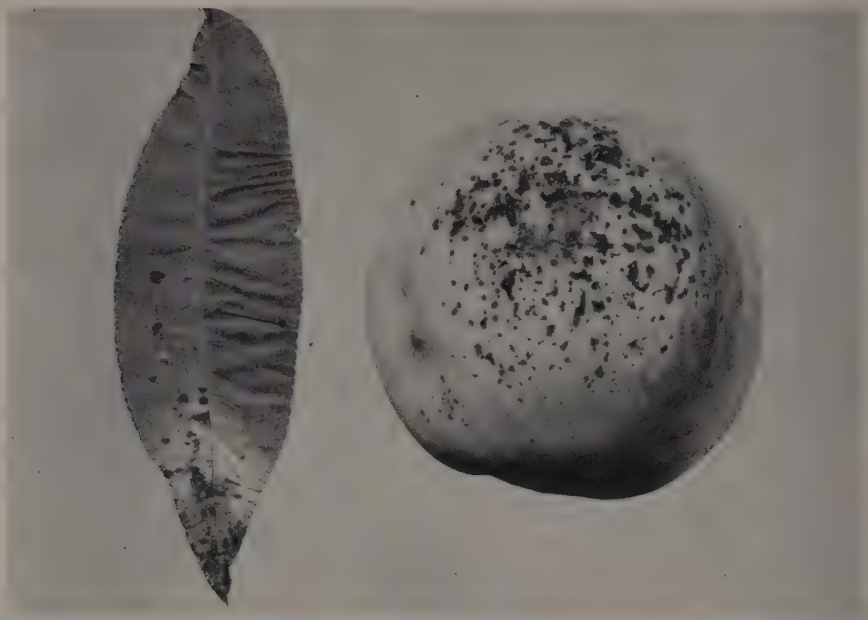

Fig. 1. Note the angular spots and light color (yellowing) at the tip of the leaf. The fruit shows the typical bacterial spot symptom close to harvest.

green fruit. There can be several cycles in a growing season depending on environmental conditions. The development and spread of the bacteria is favored by warm wet weather and driving rains.

In the fall, inconspicuous cankers are found as a result of late infections.

Control Studies

All the sprays were applied by a hand gun from a John Bean sprayer at a pressure of 500 pounds per square inch.

In the fall of 1955, several chemicals were applied to reduce the inoculum, which in turn would reduce the disease incidence if favorable environmental conditions occurred the following year. The chemicals used in 100 gallons of spray for each treatment were as follows: Bordeaux 4-6-100[2], 4 pounds of copper sulfate followed by 6 pounds of lime 1 hour later, and 1 pound of copper sulfate plus 3 ounces of Triton B1956[3].

The plots were set up in randomized two-tree plots replicated two times. The check consisted of two single-tree plots. Applications

[2] Four pounds copper sulfate + 6 pounds lime + water to make 100 gallons of spray.
[3] Triton B1956—surface-active agent.

were made on November 2. These plots received one spray of zinc sulfate (8 pounds) and lime (8 pounds) in water to make 100 gallons of spray on August 3, 1956. Leaf and fruit infection counts were made on Setpember 6, 1956.

In summer of 1956 several spray chemicals were tested as protectants in the control of this disease (Table 1). The randomized plots consisted of three trees replicated two times with the exception of the Captan and Streptomycin plots. They were replicated three times with two trees in the third replicate. The checks consisted of one- and two-tree plots. Three sprays were applied on the following dates: June 8, July 27, and August 3. Leaf and fruit infection counts were made on September 6 just prior to harvest.

TABLE 1—Chemicals and their rates used in bacterial spot control, Bob Anderson farm, Covert, Michigan, 1956

SUNSET VARIETY

Treatment	Rate per 100 gallons of spray	Source
Niacide Z-65	3 lb.	Niagara Chemical Division
Albomycin (a)	100 p.p.m.	The Upjohn Co.
Captan	4 lb.	Stauffer Chemical Co.
Zinc Sulfate+lime	8 lb.+8 lb.	Tennessee Corp.
Streptomycin sulfate+Captan	100 p.p.m.+3 lb.	.....
Streptomycin sulfate	100 p.p.m.	Merck and Co., Inc.

(a) Albomycin dropped from the schedule after the first spray.

In 1957 the promising materials of the 1956 test along with several other compounds (Table 2) were applied as a protective schedule. Randomized three-tree plots were used for each treatment and for the check. The treatment plots were replicated three times. Three sprays were applied on the following dates: May 29, June 10, and July 12.

In all tests, 10 leaves from each of 10 terminals picked at random from around each tree were inspected for leaf spot symptoms. Twenty-five fruits were inspected at random around the tree for fruit symptoms of this disease.

No disease development was found in the 1957 test. However, data on spray injury on foliage were collected on June 21. The injury was rated from 4-1 with 4 indicating no injury.

TABLE 2—Chemicals and their rates used in bacterial spot control, H. Zollar farm, Benton Harbor, Michigan, 1957

EARLY HALE HAVEN VARIETY

Treatment	Rate per 100 gallons of spray	Source
Nu-Z	3 lb.	Tennessee Corp.
Streptomycin sulfate	100 p.p.m.	Merck and Co., Inc.
Niacide Z-65	3 lb.	Niagara Chemical Division
Nu-Z+Glyodin	3 lb.+1 pt.	Carbide and Carbon Chemicals Co.
Cyprex	1 lb.	American Cyanamid Co.
Sequestrene Na_2Zn	2 lb.	Geigy Agricultural Chemicals

RESULTS AND DISCUSSION

In the fall eradication study of 1955 it was shown that no treatment had any significant difference in disease control (Table 3).

TABLE 3—Comparative control by fall sprays

Treatment	Number of infected fruit (mean)	Number of infected leaves (mean)
Bordeaux 4-6-100	5.9	17.5
Copper sulfate 4 lb.+6 lb. lime 1 hr. later.	8.4	24.9
Copper sulfate 1 lb.+3 oz. B1956	5.0	20.5
Check (no fungicide)	4.1	18.0
L.S.D.—	none	none

The 1956 test with protectants (Table 4) demonstrated the potentiality of two new chemicals in the control of bacterial spot on peach fruit and foliage. These compounds are Streptomycin sulfate and Niacide Z-65. The Zinc sulfate-lime was comparable to Niacide Z-65 and Streptomycin was superior to both these chemical sprays. The Captan alone gave poor control, but the Captan plus Streptomycin gave significant control. These results indicate that the Streptomycin in the mixture gave the disease control.

None of the sprays gave significant control of the disease in fruit.

In addition to Streptomycin and Niacide Z-65 two new materials, Cyprex and Sequestrene Na_2Zn, were tested in 1957 along with the standard Nu-Z. Nu-Z was substituted for zinc sulfate and lime be-

TABLE 4—Comparative leaf and fruit disease control with protective fungicides

Treatment	Number of infected fruit (mean)	Number of infected leaves (mean)
Niacide Z-65	5.0	34.8
Albomycin	n.s.(*a*)	n.s.
Captan	8.4	50.5
Zinc sulfate+lime	4.9	31.6
Streptomycin sulfate+Captan	6.8	29.0
Streptomycin	4.3	17.0
Check (no fungicide)	8.5	47.5
L.S.D.—.05	n.s.	14.2
L.S.D.—.01	n.s.	21.5

(*a*) Not significant.

cause of its ease of handling and compatibility with various insecticides. No leaf spot developed in the plots. However, on June 21, injury ratings were made in all the plots (Table 5).

TABLE 5—Leaf injury rating of the comparative sprays

Treatment	Injury rating (mean)
Nu-Z	2.7
Streptomycin sulfate	4.0
Niacide Z-65	4.0
Zinc Sequestrene Na_2Zn	4.0
Check	4.0
Cyprex	3.6
Nu-Z+Glyodin	3.3
L.S.D.—.05	.7
L.S.D.—.01	.9

This test showed that Nu-Z alone gave highly significant leaf injury. The addition of Glyodin to the Nu-Z spray reduced the injury but it still was significant. All the other sprays had no or very little leaf injury at this time.

The preliminary data of postharvest copper sprays indicate that no reduction of bacterial spot was found in the different treatments. It is possible that these sprays were applied too late to reduce the number of overwintering cankers. However, unpublished data showed that earlier copper sulfate spray applications resulted in severe de-

foliation whether applied alone or followed by lime spray. Early defoliation is undesirable because it could predispose the trees to winter injury.

Davis[4] showed that Captan (4 pounds) alone and Captan (2 pounds) + Streptomycin (150 p.p.m.) gave significant control against fruit infection. The Michigan test in 1956 gave significant leaf control when Streptomycin was used alone or in combination with Captan. Very little fruit infection appeared in all the test plots including the check. This can be attributed to the dry weather conditions early in the growing season.

SUMMARY

The fall copper sprays, copper sulfate (4 pounds) followed by lime (6 pounds) 1 hour later, Bordeaux 4-6-100, and copper sulfate + Triton B1956 gave no control of bacterial spot.

Summer sprays of Niacide Z-65 were comparable in control to the zinc sulfate and lime combination. Streptomycin (100 p.p.m.) in the 1956 test gave good control against leaf infection. Niacide Z-65 and Streptomycin warrant further study particularly on timing of applications.

The Nu-Z plots showed severe leaf injury in 1957. It is suggested this spray be discontinued under Michigan conditions.

[4] Davis, H. Robert (1956). Bacterial spot of peach *(Xanthomonas pruni)* and its control by the use of Captan and Streptomycin. Pl. Dis. Rptr. 40:335-336.

THE EFFECT OF NUTRIENT LEVEL ON GROWTH OF PICKLING CUCUMBERS[1]

By S. K. RIES and R. L. CAROLUS

DEPARTMENT OF HORTICULTURE

PICKLING CUCUMBER fertilizer investigations have generally been concerned more with studies on rate of application than with the proper level of N-P_2O_5-K_2O required in a balanced fertilizer for maximum productivity of the crop.

Wittwer and Tyson (1950) conducted fertilizer trials at three locations in Michigan and concluded that a banded application of 500 pounds per acre of 3-12-12 was profitable on productive soils, and that additional nitrogen was beneficial only on poorly drained soils of low fertility.

Cooper and Watts (1934) concluded from extensive tests that phosphorus followed by nitrogen was most often the limiting nutrient for pickling cucumbers. However, on a high producing field, Reynolds (1954) obtained no response from the use of any of the major nutrients or from calcium, magnesium, and boron.

Miller (1957) noted that 200 and 400 pounds of 5-20-20 per acre placed 2 inches under the seed reduced stand and yield, and that 100 pounds of potash per acre depressed yield. In these experiments the largest yields were obtained with 100 or 200 pounds per acre of a 5-20-20 fertilizer placed 2 inches to the side and 2 inches below the seed, or with 300 pounds of 5-20-20 broadcast before planting.

In the same study, an inverse relationship between the soluble nitrogen and soluble phosphorus in cucumber petioles was found in plants from 19 fields, with phosphorus increasing and nitrogen decreasing during the season. The largest yields were associated with a moderate level of both soluble nitrogen and phosphorus in the petioles of the plants (500-700 p.p.m. NO_3-N and 75-100 p.p.m. P).

In a pickling cucumber study involving spacing, Ries (1957) observed that supplemental fertilizer applications, in addition to an

[1]These investigations were supported in part by the National Pickle Packers Association.

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initial application of 300 pounds per acre of 5-20-20 broadcast prior to planting, was without effect in one season. However, they increased the early yield by 52 bushels per acre in a season of heavy rainfall.

In the following field experiments the effects of various levels of phosphorus, potassium, and nitrogen on yield and soluble nutrients in the plant tissue were determined.

THE INFLUENCE OF POTASSIUM ON PICKLING CUCUMBERS

Methods

The potassium study was laid out factorially in three replications on a Hillsdale sandy loam having a pH of 6.3 and testing 23 and 72 pounds per acre of phosphorus and potassium, respectively, by the Spurway reserve method. The potassium level was varied and some plots received supplemental applications of nitrogen and magnesium as indicated in Table 1.

TABLE 1—The influence of potassium, nitrogen, and magnesium on the yield and nutrient content of the pickling cucumber (averages of three replicants)

Fertilizer (pounds per acre)				Yield Bu/A.	Petiole content soluble nutrients (p.p.m.)		
N	P_2O_5	K_2O	MgO		N	P	K
0.....	0	0	0	288	950	15	5,200
20.....	80	0	0	342	900	17	5,800
20.....	80	0	100	364	990	27	6,100
20+40..	80	0	0	327	1,100	15	5,200
20+80..	80	0	0	340	1,000	29	5,300
20.....	80	80	0	440	280	18	7,000
20+40..	80	80	0	441	890	25	6,400
20+80..	80	80	0	402	910	21	7,000
20.....	80	160	0	356	920	18	7,300
20.....	80	160	100	360	500	15	7,700
20+40..	80	160	0	451	1,050	19	7,400
20+80..	80	160	0	408	740	13	7,400
L.S.D. at 5 percent.....See Table 2					560	NS	1,100
L.S.D. at 1 percent.....					NS	NS	1,500
Coefficient of variation (percent).....				13	31	41	9

A commercial 5-20-20 fertilizer was used at the rate of 400 pounds to the acre on the plots supplied with 80 pounds of K_2O, and was supplemented with sulfate of potash on the plots that received 160 pounds

of potash. Forty-five percent super phosphate and ammonium nitrate were used on the plots that received no potash. Ammonium nitrate provided the supplemental nitrogen, and magnesium sulfate mixed in the fertilizer supplied the magnesium.

The fertilizers were broadcast by hand on plots 12 feet wide and 30 feet long, and then disced into the soil. On the same day, June 6, seed of the variety Wisconsin CMR-12 was drilled with a Planet Junior seeder, in two rows, 4 feet apart in the center of each plot. Guard rows, 4 feet from the test rows, were located on the plot margins. Plants were thinned to approximately 1 foot apart. Supplemental nitrogen applications totaling 40 pounds per acre in each application were made on July 1 and August 2.

Rainfall was as follows: June, 2.20 inches; July, 8.44 inches; and August, 1.42 inches. There was a concentrated period of precipitation from July 5 to July 13, when 6.78 inches fell.

Weeds were controlled with Alanap-3; beetles with methoxychlor. Weekly sprays, after vining, of tribasic copper and Karathane were used to prevent angular leaf spot and powdery mildew, respectively.

Samples of ten petioles were taken on July 23 from the central portion of 10 randomly selected plants from each plot, extracted immediately, and analyzed[2] for their soluble nitrogen, phosphorus, and potassium contents (Carolus, 1938). The crop was harvested nine times at approximately 3-day intervals from July 24 to August 22 when damage from powdery mildew made further harvests impractical.

The weights of marketable cucumbers up to 2 inches in diameter were recorded. For a comparison of early and late yields, the first four and last five harvests from each plot were combined for the analysis of variance.

Results

Total yields and the soluble nutrient content of the petioles for each treatment are presented in Table 1. Even with a low P and K soil test, the yield on the unfertilized plots was at the rate of 288 bushels per acre. This high yield suggests that lack of soil fertility may not be the most limiting factor in pickling cucumber production in Michigan, since the average yield in the state is about 100 bushels per acre.

There was no increase in yield from the application of either magnesium or supplemental nitrogen, although it appears that the addition

[2]The assistance of J. P. Shugars and J. E. Ells in running the chemical determinations is acknowledged.

of supplemental nitrogen counteracted some detrimental effect of high potassium. However, these yields were not statistically higher than where only 80 pounds per acre of potassium were applied.

In Table 2, the early, late, and total yields for varying potash levels are given. An application of 20 pounds of nitrogen and 80 pounds of phosphorus increased the total yield 53 bushels to the acre over that harvested from unfertilized plots. A further increase of 86 bushels per acre occurred with the addition of potassium at the rate of 80 pounds per acre. Increasing the rate to 160 pounds per acre did not give an additional increase in yield.

Variations in yield between treatments for the different harvest periods indicate that more pickles were harvested early, July 24 to August 5, than during the late harvests, August 8 to August 22, from all treatments receiving fertilizer. Only on the unfertilized plots was the early yield lower than the late yield, indicating that the lack of either nitrogen or phosphorus or both probably delayed maturity.

The petiole analysis for soluble potassium indicates that, in general, the plots receiving potash fertilizer produced higher yields and had more potassium in their petioles than those receiving no potash (Table 1).

TABLE 2—Early, late, and total yields of pickling cucumbers as influenced by potassium level

Fertilizer	Petiole content soluble K (p.p.m.)	Yield		
		Harvest period*		Total**
		Early	Late	
No fertilizer	5,200	129	159	288
No potassium	5,600	183	158	341
80 lb. of potassium	6,800	237	190	427
160 lb. of potassium	7,450	210	183	393

*F value for interaction of level of potash and time of harvest significant at 5 percent level.
**F value for difference between levels significant at 1 percent level.

A comparison of plots fertilized with 160 and 80-pound rates of potash indicates that there was neither an appreciable increase in the potassium content in the petioles of plants nor in the yield of those receiving the 160-pound rate. Apparently 80 pounds of potash per acre were sufficient under the conditions of this experiment. With the highest potash application, additional nitrogen evidently brought

the nitrogen-potash level into better balance for plant growth, as indicated by an increase in productivity.

The amount of soluble-N in the petioles (Table 1) was lowest in plants receiving 80 pounds of potassium and 20 pounds of nitrogen per acre. However, since this low level of soluble-N in the petioles was associated with a high yield, it is indicative of an efficient level of utilization. As the plants from plots where no fertilizer was applied averaged higher in soluble-N than those from the highest yielding plots, it would appear that nitrogen was not the first limiting factor.

THE INFLUENCE OF PHOSPHORUS ON PICKLING CUCUMBERS

Methods

The phosphorus study was laid out factorially in two replications on three adjacent fields differing in elevation and in other characteristics listed in Table 3. Phosphorus application and method of placement were varied with two plots receiving supplemental applications of nitrogen as indicated in Table 4.

As in the potash study, 400 pounds to the acre of a commercial 5-20-20 fertilizer was used on plots receiving the 80 pound level of

TABLE 3—Soil characteristics, cultural practices, on yields from fields used in a phosphorus study with pickling cucumbers

Soil type	Field		
	A	B	C
	Hillsdale sandy loam	Locke sandy loam	Locke sandy loam
Soil pH value	6.3	6.3	6.3
Reserve	23	92	92
Reserve K test	72	160	148
Crop in 1956	Corn	Potatoes	Potatoes
Cover crop	None	Rye	Rye
Fertilizer turned under	None	55 lb. of N.	None
Early yield**	151	141	124
Late yield**	194	212	243
Total yield	345	353	367

**F value for interaction of field and harvest period significant at 1 percent level.

TABLE 4—Effect of rate, method of phosphorus application, and supplemental nitrogen on yield (averages of six observations)

Fertilizer (pounds per acre)			Placement (*c*) of P_2O_5	Yields (bushels per acre) Harvest Period**		
N	P_2O_5	K_2O		Early 7/23-8/5	Late 8/8-8/22	Total
0	0	0	..	85	186	271
20	0	80	..	102	199	301
20	80	80	BC	154	207	361
20	160	80	BC	179	237	416
20	80	80	SP	117	213	330
20	160	80	SP	158	245	403
20+80 (*a*)	160	80	BC	159	232	391
20+80 (*b*)	160	80	BC	157	214	371
			Interaction			
L.S.D. at 5 percent				25		43
L.S.D. at 1 percent				34		58
Coefficient of variation				9 percent		10 percent

**F value for interaction of harvest period and treatment significant at 1 percent level.
(*a*) Supplemental nitrogen as Uramite.
(*b*) Supplemental nitrogen as ammonium nitrate.
(*c*) BC = broadcast; SP = sideplaced.

P_2O_5. Potassium chloride and ammonium nitrate were used on plots that received no phosphate and on the plots on which the phosphate was sideplaced. Double superphosphate was used to obtain the 160 pound rate.

The supplemental nitrogen treatments compared two sources of nitrogen at the high phosphorus level (Table 4). Ammonium nitrate was applied twice at monthly intervals and Uramite, a slowly available nitrogen source, at the time of planting. Forty-five percent superphosphate was sideplaced on June 10 in a small furrow 2 to 4 inches to the side of the planted row and 2 to 3 inches below the seed level.

The plot size, cultural practices, pest control, and petiole sampling were the same as described for the potash experiment. Harvests were started on July 23 and concluded on August 22. The first five harvests were compared with the last five harvests in the analysis of variance.

Results

In the analysis of variance of the yield data, it was not possible to test for the difference between the three fields because they could

not be replicated. As shown in Table 3, the early and late yield varied considerably on the three fields in the experiment, but total yields were not materially different.

The many known soil variations among the three fields made it impossible to ascribe the yield differences to one factor. In addition, field A was 6 to 8 feet higher than field C. It is possible that this factor, associated with soil moisture and temperature differences, was partially responsible for the differences in maturity observed.

A summary of the total yields for all treatments on the three soils is presented in Table 4, along with the average of the early and late harvests for each treatment.

The use of 400 pounds per acre of a 5-20-20 fertilizer increased the yield on all three soils compared to no fertilizer, or to one lacking in phosphorus. There were no significant effects from placement of fertilizer or from supplemental applications of either form of nitrogen on total yields.

Fig. 1. Plots showing difference in growth from varying applications of fertilizer 36 days after planting. Foreground, 400 pounds per acre of 5-0-20, yield of 301 bushels per acre; middle, no fertilizer, yield of 271 bushels per acre; background, 400 pounds per acre of 5-40-20, yield of 416 bushels per acre.

The yields from the various treatments varied for the two harvest periods. The early yield where no fertilizer was applied was relatively lower than the late yield. The sideplacement of phosphorus depressed early yield and increased late yield as compared to broadcast application at either rate.

The application of either form of supplemental nitrogen did not affect either the early or late yield. Fig. 1 shows the poor early vine growth on an unfertilized plot compared with a plot receiving only nitrogen and potash, and one receiving a complete fertilizer.

The results of the petiole analyses are presented in Table 5. There were no significant differences among treatments in soluble nitrogen, soluble phosphorus, or potassium. However, the level of soluble phosphorus varied with treatments in the three fields. Where the phosphorus was broadcast, rather than sideplaced, petioles from plants in field A were lower in soluble P than those from comparable plots in fields B and C.

TABLE 5—Effect of phosphorus treatments and supplemental nitrogen on the nutrient content in the petioles of pickling cucumbers

Fertilizer (pounds per acre)				Soluble nutrients (p.p.m.)				
N	P_2O_5	K_2O	Placement of P_2O_5	N	P** Field			K
					A	B	C	
0	0	0	...	1,127	19	46	86	7,617
20	0	80	...	1,031	24	54	85	7,950
20	80	80	BC	1,057	16	54	78	7,433
20	160	80	BC	848	16	76	75	7,717
20	80	80	SP	840	88	67	58	7,550
20	160	80	SP	990	73	77	50	7,433
20+80 (*a*)	160	80	BC	970	38	59	68	7,917
20+80 (*b*)	160	80	BC	1,060	27	81	71	7,583
					LSD for Diff. of difference			
L.S.D. at 5 percent				NS	41			NS
L.S.D. at 1 percent				NS	56			NS
Coefficient of variation				18 percent	24 percent			8 percent

**The F value for the interaction of field and treatments significant at the 1 percent level.
(*a*) Supplemental nitrogen as Uramite.
(*b*) Supplemental nitrogen as ammonium nitrate.
(*c*) BC = broadcast; SP = sideplaced.

By the Spurway reserve test, field A contained 23 pounds and fields B and C 92 pounds of P per acre. This indicated that under conditions of rapid early growth in field A, broadcast applications of phosphorus were not as readily available to the plant as sideplaced applications.

GENERAL DISCUSSION AND CONCLUSION

An investigation of the nutrient requirements of pickling cucumbers was conducted in 1957 on the horticultural farm at East Lansing. The yields indicated that 20 pounds of nitrogen, 80 to 160 pounds of phosphate and 80 pounds of potash were adequate quantities of these nutrients to produce over 400 bushels to the acre. On these fields of above average productivity, supplemental nitrogen applications were of no benefit in a season of above average rainfall.

Phosphate applications of 160 pounds compared to 80 pounds to the acre caused no reduction in yield on any of the three fields studied. It is suggested that the optimum quantity of phosphorus might be 160 pounds per acre for field A and about 120 pounds for fields B and C.

Yield and chemical analyses suggest that more than 80 pounds of potash per acre may have been beneficial if combined with a high level of nitrogen. Results also indicate that equal yields could be obtained with 80 pounds of potash and 20 pounds of nitrogen.

On soils in which the potash level is higher than the amount available in the experimental fields, the nitrogen should probably be increased above the amount suggested by this study. A potash soil test of 150 to 200 pounds per acre might indicate that a 40 pound application of potash would be sufficient.

On field A, where soil tested 23 for phosphorus and 72 for potassium, both appeared to limit growth equally. On fields B and C, with phosphorus values of 92 and potassium values of 160 and 148, respectively, phosphorus appeared to be the more limiting nutrient.

Soluble phosphorus analyses of petioles prior to the first harvest indicated that on fields with a low phosphorus test, the method of application influenced the level in the plant. On the field low in phosphorus, plants accumulated more from sideplaced than broadcast sources; but on the fields with the higher soil phosphorus values, method of placement did not influence the level of accumulation. Sideplaced phosphorus applications would appear to be most desirable on fields showing a low phosphorus soil test.

When the principle nutrients are in optimum proportion to each other, early maturity is related to maximum yield. In this experiment, the 20-160-80 (N-P-K) treatment fulfilled both of these requirements.

There are two possibilities of closely approximating this nutrient level with currently available fertilizers. Six hundred pounds per acre of a 4-24-12 fertilizer could be broadcast. One hundred and fifty pounds per acre of muriate of potash broadcast, plus 300 pounds per acre of ammonium phosphate sideplaced would also be satisfactory.

Good yields ranging from 361 to 440 bushels per acre were obtained with broadcast applications of 400 pounds per acre of a 5-20-20 fertilizer on the four fields studied. However, the results of this study show that a 5-20-10 fertilizer could probably be substituted for 5-20-20 on fields testing over 150 pounds of potash per acre.

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ECONOMICS OF IRRIGATING CORN

By C. R. HOGLUND[1]
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UNDER WHAT CONDITIONS does it become profitable for a farmer to irrigate corn? How much of an increase in yields can he expect when he applies irrigation water, and more fertilizer, seed, and labor on soils with different water-holding capacities? How important is the relative price of corn in determining the profitability of irrigation? These are but a few of the questions farmers need answered to decide whether to invest in an irrigation system. They also need to consider the earning power of equal investments in other alternatives.

Corn and other feed crops are relatively low in value compared to fruit and truck crops which are irrigated quite extensively. If, for example, we assume a 60 percent increase in yields resulting from irrigation, the gross value of the increased production per acre would be about $30 to $60 for corn and $100 to $200 for potatoes. It costs more to produce the extra potatoes than the corn but there is usually a larger margin left to pay labor and interest on the investment for potatoes and other high-value crops.

The major purpose of this study was to determine the effect on net income of irrigating corn under different situations for the water supply, soil, and prices.

During 1956 and 1957, a study was made of the irrigation operations on a small number of cash-feed-crop farms in southern Michigan. Detailed information was obtained on water sources, investments in irrigation equipment, yields, and receipts and expenses associated with the irrigation of corn. Seven Indiana farmers who have irrigated corn for several years were visited during 1957. Additional information on crop yields, and irrigation and fertilizer practices were obtained from agronomists, agricultural economists, agricultural engi-

[1] The author acknowledges helpful suggestions and assistance received from E. C. Rossman of the Department of Farm Crops, A. E. Erickson and I. F. Schneider of the Department of Soil Science; E. H. Kidder of the Department of Agricultural Engineering and K. T. Wright of the Department of Agricultural Economics at Michigan State University; and D. W. Thomas of the Department of Agricultural Economics and D. Wiersma of the Department of Agronomy at Purdue University. Bernard Brown and Dean Tribby assisted in the field work.

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neers, and soil scientists from Michigan State University and Purdue University.

VARIABILITY OF YIELDS AND RAINFALL

An important reason why many farmers have shown an increased interest in irrigation in recent years stems from a desire to reduce weather risks in producing crops. Year to year corn yields on the sandier soils such as Fox sandy loam and Kalamazoo sandy loam range from less than 25 bushels to more than 80 bushels. These yield variations are less severe on the more productive soils.

During very favorable climatic conditions when rainfall is ample and well-distributed, non-irrigated corn may yield nearly as much as irrigated corn. Corn hybrid tests conducted during 1956 on a farm in St. Joseph County showed only 8 bushels greater yield on the irrigated corn (Rossman, E. C. and G. E. Carter, 1956). Climatic conditions were very favorable during 1956 for corn production. The soil

Fig. 1. The profitability of irrigating corn and other feed crops depends on using more seed and fertilizer. Irrigation reduces the risk of crop failures on the sandier soils.

on this farm was Warsaw sandy loam, a soil with low water-holding capacity. Irrigation increased corn yields by more than 40 bushels during the less favorable years.

Both the frequency and length of periods in which no rainfall occurs affect corn yields. Humidity, temperature, and wind are additional factors influencing yields. Forty-five years of weather data from East Lansing, Michigan show that periods of 1 week (5 to 9 days) with less than .2 inch rainfall per day occur several times each year during the 4-month period, June 1 to September 30 (Table 1).[2] These weekly periods without rain occurred most frequently during July, August, and September.

TABLE 1—Occurrence of various periods with less than .2 inch of rainfall per day for the months June, July, August, and September, 45 year period, 1911-1955, East Lansing, Michigan (a)

Consecutive days with less than .2 inch per day	Number of years occurring	Total number of times occurring
1 week (5-9 days)	45	164
2 weeks (10-19 days)	42	134
3-4 weeks (20-29 days)	19	20
Over 4 weeks (30 or more days)	6	8

(a) Based on weather data from A. H. Eichmeier, State Climatologist, Weather Bureau Office, East Lansing, Michigan.

Periods of 2 weeks without rain were noted 42 out of the 45 years. During 17 of these years, 2-week dry periods occurred 4 or more times during the growing season. Two to 3 weeks without rain were reported for 19 or slightly more than 1 in 3 years. Dry periods of 30 or more days occurred once every 9 years. When extended periods of no rainfall occur, particularly during the tasseling and silking stage, corn yields are greatly reduced.

Agronomists estimated that from 20 to 24 inches of water are needed during the growing season to produce 80 to 100 bushels of corn per acre. This is the quantity of water used by plants or lost by evaporation (Odell, R. T., 1956). Rainfall during the growing season often totals only 10 to 15 inches.

The need for supplementary irrigation depends on the distribu-

[2] Data from A. H. Eichmeier, State Climatologist, Weather Bureau Office, East Lansing, Michigan.

tion of the rainfall as well as the total quantity. For high corn yields, soils must store moisture and release it as it is needed. Soils vary greatly in their water-holding capacities, depending on structure, texture, and quantity of organic matter present. The inches of available water stored in the rooting depth of corn grown on a select group of Illinois soils ranged from a low of 5 inches on the sandier soils to 14 inches on Muscatine silt loam, a productive, loess-formed soil. For Michigan soils, the inches of readily available water ranges from less than 4 to more than 17 (Erickson, A. E.). Depth of rooting is influenced by the physical characteristics of the soil profile as well as by fertilizer application and soil treatment.

PROFITABLE IRRIGATION PRACTICES

The extent to which it may pay to irrigate corn depends on several important factors. Timeliness in applying irrigation water is important. A common mistake often made by beginning irrigators is to attempt to cover more acres than their system is engineered for or to operate with too little labor. During extended periods without rain,

Fig. 2. A crew of three move irrigation pipe with a minimum of time and effort when driving strips are used. These crews can be used most economically on farms where large acreages of corn are grown.

particularly during the tasseling and silking stages, it may be necessary to make complete irrigation cycles every 7 to 10 days.

A practice which has proven profitable in the western part of the corn belt is to apply a pre-season application of water on the land which cannot be adequately irrigated during the growing season (Ramig, R. E., 1957). This practice has been used to a limited extent in Michigan during drought periods when moisture during the non-growing season was not adequate to restore ground moisture to normal levels.

Irrigation of corn is more difficult and time consuming than irrigation of most other crops. Moving lateral lines to new locations can be speeded up considerably and drudgery reduced when driving strips are established where the lateral lines are to be placed. Some farmers have left 7- to 10-foot sod strips 180 feet apart. Four to 5 percent of the field is thus used for driving a tractor, truck, or jeep when pipe is moved.

A crew of three men was used in moving pipe on the larger irrigation operations observed. One man drove the power unit and the other two loaded or unloaded pipe. A crew of this size could not be profitably employed except on farms where large acreages of corn and other crops are produced. One of the men moved sprinklers when he was not assisting in moving pipe. From 2 to 3 inches of water were usually applied at each setting in irrigating corn. Lateral lines were moved to a new location two or three times a day, depending on the number and capacity of the sprinklers used and the quantity of water applied.

CORN YIELD RESPONSES TO IRRIGATION

Corn yields are influenced not only by the quantity of water available, but also by the stalk population and quantity of fertilizer applied. Agronomists suggest that an optimum stalk population for the sandier soils such as Fox sandy loam are about 12,000 to 14,000 without irrigation and 18,000 with irrigation. Comparable figures for moderately productive soils such as Miami silt loam are 16,000 without irrigation and 18,000 with irrigation. The available water-holding capacity of Fox sandy loam is low and of Miami silt loam is moderate.

It is estimated that under price relationship existing during 1957, it would pay to apply 200 pounds more fertilizer on the irrigated corn at pre-planting or planting time for the Fox soils and 150 pounds for the Miami soils.[3] Increases of 60 pounds of nitrogen applied on

[3] The analysis of this fertilizer would be determined by soil tests.

the Fox sandy loam and 40 pounds applied on the Miami silt loam soils were used in calculating the additional expense of sidedressing the irrigated corn.

Experimental data and farmer experiences indicate that under average weather conditions corn yields on Fox sandy loam soils can be increased by 40 to 60 bushels per acre by irrigation, a higher stalk population, and the use of more fertilizer. A 2-year study in Indiana on Plainsfield sand, a very droughty soil, resulted in an increase of 77 bushels of corn per acre in favor of irrigation (Crane, P. L., J. E. Newman and S. R. Miles, 1956). During 1956, when climatic conditions were better than normal during the growing season, the irrigated corn produced 51 bushels more than the non-irrigated corn.

It is estimated that corn yields can be increased by 25 to 30 bushels per acre when irrigation water is applied to corn grown on Miami silt loam soil.[4] Average acreage increases of 50 bushels for the Fox sand loam and 28 bushels for the Miami silt loam were used in calculating the additional returns resulting from irrigation.

Fig. 3. An inexpensive source of water such as a reservoir, stream, or lake is one of the important factors determining the profitability of irrigating corn and other feed crops.

[4] Based on limited research data and farmer experiences on soils having essentially the same water-holding capacities.

IRRIGATING LARGE ACREAGES OF CORN

The economic consequences of investing in an irrigation system and the irrigation of 150 acres of corn has been tested out for farms with Fox sandy loam and Miami silt loam soils. A farm with this acreage of corn was selected for study because labor and equipment would be used very effectively.

It probably would not be economical to irrigate as few as 40 or 50 acres of corn if no other crops were irrigated. An exception to this is corn grown for seed, a high-value crop. Investments and annual expenses in owning and operating an irrigation system were calculated with water supply from a reservoir and from a deep well.

Changes In Investments

Two large reservoirs which are fed by springs, streams, or underground water would be needed for the irrigation of 150 acres of corn. Careful planning assures a continuous supply of water. The water supply must be adequate for an extended drought period. It requires 30,000 gallons to put 1 inch of water on 1 acre, allowing for losses in evaporation and maldistribution from applicators.

It has been suggested that to apply 8 inches of water per acre for the season, 280,000 gallons would be needed when allowance is made for losses in getting water to the crop (Muirheid, B. F., 1957). The cost of constructing two reservoirs was estimated at $800. The cost of a deep well, 10 inches in diameter and 200 feet in depth, was calculated at $2,400. The investment in a water supply would vary greatly between farms.

The investment in a complete irrigation system totaled $10,300 when water was obtained from reservoirs and $13,300 for the system with a deep well (Table 2).

The investment for a complete system using a river or lake as a source of water supply would be about the same as for the system using reservoirs. Extra cost of 40 rods of main line pipes is estimated to equal the cost of constructing two reservoirs. Many farmers do not have access to a surface source of water and thus must invest in the more expensive deep well.

TABLE 2—Investment and annual expenses in owning an irrigation system for 150 acres of cropland, two sources of water

Investment item	Source of irrigation water			
	Reservoirs		Deep well	
	Investment	Annual expense (*a*)	Investment	Annual expense (*a*)
Water supply.....	$ 800	$ 80	$ 2,400	$ 144
Irrigation equipment...	9,500	737	10,900	877
Total investment ..	10,300	817	13,300	1,021

(*a*) Depreciation and repairs. A 15-year life for the irrigation equipment and 30-year life for the well was used as a basis for determining depreciation. Annual repairs on the pump and power unit and well were calculated at 3 percent of the investment.

Changes In Receipts And Expenses

The value of the additional corn produced with irrigation has been valued at three prices; namely, $1.00, $1.20, and $1.40 per bushel (Table 3). Each 10 cent change in the price of corn would add to or subtract $750 from gross receipts for the farm with Fox sandy loam soil. A similar price change would increase or decrease gross receipts by $420 on the farm with Miami silt loam soil.

Only those expenses that changed as a result of owning and operating the irrigation system were calculated. Depreciation, repairs, and interest on the additional investment added $1,132 for the system with reservoirs and $1,420 for the system using a deep well (Table 3). Fuel and lubricants used in applying 8 inches of water on the corn produced on the Fox sandy loam soil added from $1,050 to $1,200 to expenses. These extra expenses were only half as high when 4 inches of water were applied per acre on the corn produced on the Miami silt loam soil.

Fertilizer and seed added more to expenses than any other item. Cost of harvesting and hauling the extra corn produced was calculated at 8 cents per bushel. Extra labor used in moving irrigation pipe was charged at $12 per day. It was estimated that the equivalent of 80 days of hired labor would be needed in irrigating the 150 acres of corn grown on the Fox sandy loam soil. This would be reduced to 60 days on the farm with Miami silt loam soil. The extra expenses in owning and operating the irrigation system, and supplying the extra seed, fertilizer, and labor added $30 to $43 per acre to the total expense.

With corn valued at $1.00 per bushel, net income would be increased by $1,508 when water was obtained from reservoirs and applied to 150 acres of Fox sandy loam soil (Table 3). When it was necessary to invest in a deep well, net income was increased by $1,070. The investments in an irrigation system on the farm with Fox sandy loam soil, with corn priced at $1.00 per bushel, earned 18 percent and 11 percent, respectively for the systems using reservoirs and a deep well as sources of water.

Fifteen hundred more dollars were added to net income at the $1.20 price for corn. Investment in irrigation equipment on the farm with the sandier soil would be extremely profitable if corn sold at $1.40 per bushel. On the basis of the calculated changes in production and expenses, an investment in irrigation equipment would not be profit-

TABLE 3—Estimated changes in production, and annual receipts and expenses when 150 acres of corn are irrigated, southern Michigan, Fox sandy loam and Miami silt loam soils

Item	Fox sandy loam		Miami silt loam	
	Source of irrigation water			
	Reservoir	Well	Reservoir	Well
Additional production				
Bushels of corn	7,500	7,500	4,200	4,200
	Dollars	*Dollars*	*Dollars*	*Dollars*
Additional receipts				
Corn at $1.00 bu.	7,500	7,500	4,200	4,200
Corn at $1.20 bu.	9,000	9,000	5,040	5,040
Corn at $1.40 bu.	10,500	10,500	5,880	5,880
Additional expenses (*a*)				
Irrigation				
Depreciation and repairs	817	1,021	817	1,021
Interest on investment	315	399	315	399
Fuel and lubricants	1,050	1,200	525	600
Fertilizer and seed	2,250	2,250	1,700	1,700
Harvesting and hauling	600	600	360	360
Hired labor	960	960	720	720
TOTAL	5,992	6,430	4,437	4,800
Net increase in income				
Corn at $1.00 bu.	1,508	1,070	−237	−600
Corn at $1.20 bu.	3,008	2,570	603	240
Corn at $1.40 bu.	4,508	4,070	1,443	1,080

(*a*) Based on 1957 level of prices.

able if the price of corn dropped much below $1.00 per bushel.

Investment in an irrigation system to be used in irrigating large acreages of moderately productive soil such as Miami silt loam does not appear profitable unless the price of corn is at least $1.40 per bushel. Further research is needed to determine the responsiveness of crops to irrigation when grown on soils having medium to high water-holding capacities.

Limited research data indicate that during 1956, a year of much below average normal rainfall in western Iowa, corn yields were increased by as much as 70 bushels per acre on medium-textured soils with a high water-holding capacity (Beer, Craig and W. D. Shrader, 1956). The profitability of irrigating corn grown on soils of moderate to high water-holding capacities depends on the frequency of dry periods such as that which occurred during 1956 in portions of the western corn belt.

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GIBBERELLIN AND HIGHER PLANTS: XI

RESPONSES OF CERTAIN WOODY ORNAMENTAL PLANTS

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THE FIRST OBSERVED EFFECT of gibberellin on plants was the marked elongation of stems (Kurosawa, 1926). This increased growth rate on woody ornamental plants may prove advantageous to the nurseryman and the homeowner if there is no loss of aesthetic or marketable value.

Aside from the preliminary report of Marth, Audia, and Mitchell (1956), little information has been published concerning the effects of gibberellin on the growth and dormancy of woody plants. The present study was designed to evaluate the effects of various foliar sprays of gibberellin on woody ornamental plants. The objective was to consider not only the induced growth responses, but to observe any deleterious effects on the leaves, stems, fruit, and general shape of the plant. From these observations, suggestions which may prove useful for each crop are proposed.

MATERIALS AND METHODS

Thirteen woody ornamentals, consisting of 30 plants each, were selected on the basis of foliage type (deciduous or evergreen), growth habit, time of flowering, and commercial importance. Each of five single plant replications was sprayed with 0, 10, 100, or 1,000 p.p.m. of gibberellin as a single application or with 10 or 100 p.p.m. at weekly intervals.

The tests were conducted under the naturally occurring photoperiod during the spring and summer of 1957 in a sheltered area between the plant science greenhouses at East Lansing, Michigan. A ground bed, 6 by 50 feet, was filled with 2 to 3 inches of pea gravel

[1] The authors acknowledge the financial assistance of the Chas. Pfizer Co. in these studies. The gibberellin used consisted of a mixture of gibberellins A_1 and A_3 from the Chas. Pfizer Co., Brooklyn, N. Y.

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as a base for setting the potted plants. Snow fence was suspended 6 feet above the ground level to provide partial shade.

The plants were grown in standard clay pots varying from 4 to 15 inches, depending on the size of the plant. Each pot contained three parts loam, one part sand, and one part muck. The plants were spaced according to size in order to prevent them from shading one another. They were watered as needed.

All plant material was purchased and potted during the month of April. Between May 4 and 13, all single treatments of gibberellin and the first of the series of weekly treatments were applied.

Tween 20 (1.5 grams per liter) was added to the gibberellin solutions which were applied to all the above ground plant parts at about 100 pounds pressure, by means of self-contained air pressure sprayers. The plants were protected from rain for at least 24 hours after spraying. The weekly repeat treatments began in early May and continued until August 12, 1957.

At the time of the initial treatment, the leaves were beginning to expand and new shoot growth was 2 to 4 centimeters in length. Two shoots, or buds, one from the upper and lower parts of each plant were selected at random for weekly growth measurements. These measurements were taken from a specified node to the farthest vegetative extension.

On May 28, 100 to 400 milliliters of a solution containing 1 ounce per gallon of a commercial fertilizer[2] were added to each pot. Plants were fertilized in proportion to size. Final observations of growth, aesthetic value, and desirable or deleterious effects were made September 29.

RESULTS

Evergreen Bittersweet (*Euonymus fortunei vegetus*)

Treatment of 3-year old plants, 8 to 12 inches in height, resulted in significant differences in terminal growth, numbers of nodes, flushes of growth, and numbers of fruits (Table 1, Fig. 1, 2, 3).

The first observable response on the gibberellin treated plants was the abscission of flower buds beginning May 24. Repeat applications of 100 or single applications of 1,000 p.p.m. resulted in complete abscission. Single or repeat applications of 10 p.p.m., and a single treatment of 100 p.p.m. gave 50 percent loss compared to only a 10 percent loss in the controls. Flower abscission occurred at the

[2] The fertilizer had an analysis of 23-21-17.

TABLE 1—Woody ornamental plants that gave positive growth responses when sprayed with gibberellin

Gibberellin treatment	*Euonymus fortunei vegetus*	*Forsythia "Arnold Dwarf"*	*Ligustrum obtusifolium vicari*	*Magnolia soulangeana*	*Phellodendron amurense*	*Berberis thunbergi "Crimson Pygmy"*	*Thuja occidentalis hoveyi*	*Viburnum opulus nana*
(p.p.m.)	Total terminal growth for season (cm.)							
0 (control) ...	2.9	3.2	8.8	6.9	20.9	8.2	4.2	4.8
10 single.....	4.5	3.6	11.7	8.3	19.3	10.2	5.1*	6.2
10 weekly.....	4.9	6.4*	14.1*	8.9	21.7	12.9	5.2*	6.2
100 single.....	7.2	6.1*	13.0	13.9*	20.0	11.5	5.1*	6.9*
100 weekly....	13.5*	12.0**	29.7**	13.2*	45.0**	13.6*	3.8	7.8*
1000 single....	11.8*	8.8*	19.6*	15.5**	32.0*	11.3	4.9	5.9
	Node number							
0 (control)....	1.5	5.1	11.6	5.1	3.9	12.3	....	2.7
10 single.....	3.9*	5.7	12.7	5.0	5.0	12.0	....	2.2
10 weekly.....	4.5*	8.6*	12.0	5.0	5.9**	11.8	....	2.5
100 single.....	4.3*	8.0	12.8	5.4	5.8**	11.1	....	3.0
100 weekly....	13.3**	10.0**	13.2	5.2	11.0**	13.9	....	2.6
1000 single....	9.5*	8.5*	14.0*	5.9	7.8**	10.2	....	2.5

* or ** differ from the control values at the 5 and 1 percent levels, respectively.

base of the peduncle. On the gibberellin treated plants, the peduncles were three times the length of those found on the controls.

No fruit developed on plants receiving repeat applications of 10 or 100 p.p.m. or a single application of 1,000 p.p.m. of gibberellin. Plants sprayed once with 10 or 100 p.p.m. averaged only one to two fruits, while the controls developed an average of 133 fruits per plant.

Growth of the shoots and length of the internodes were not markedly affected by gibberellin until late June. Then a second flush of growth occurred from many terminals on plants sprayed weekly with 100 or once with 1,000 p.p.m. (Fig. 3). Those that received

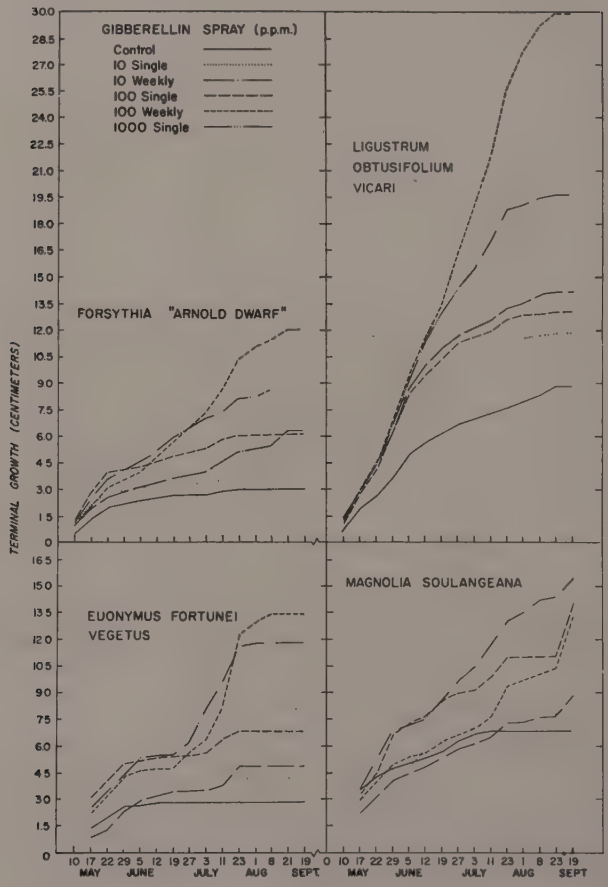

Fig. 1. Comparative growth rates of terminal shoots of four woody ornamental plants subjected to foliar sprays of gibberellin.

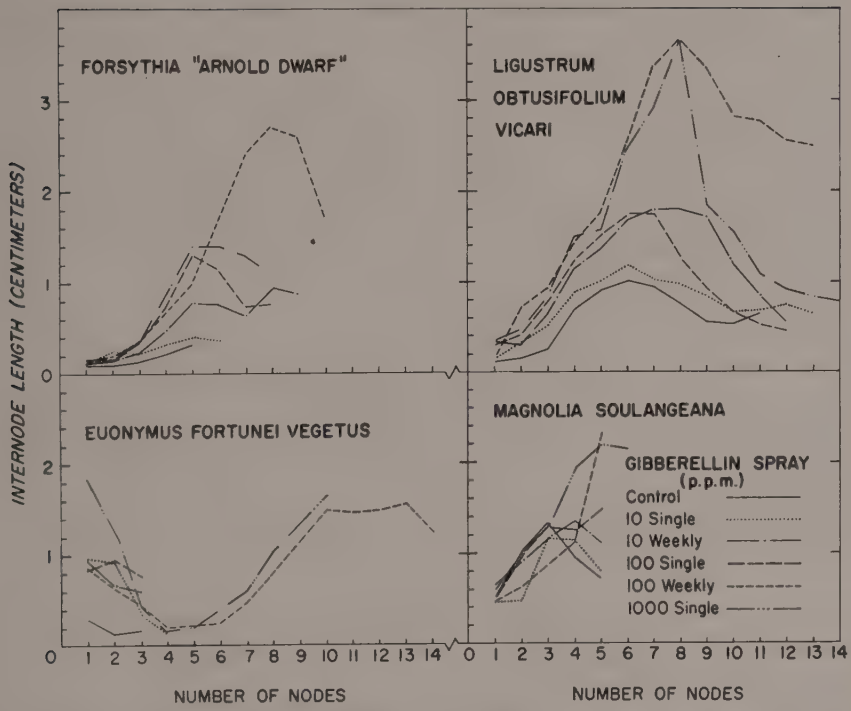

Fig. 2. The effect of foliar sprays of gibberellin on internode length and node number of four woody ornamental plants.

weekly treatments of 10 p.p.m. also produced a second flush of growth but this was very weak in most instances. Formation of the terminal buds after the second growth flush, occurred during the first week in August. With weekly applications of 100 p.p.m., there was a reduction in the total number of shoots per plant compared to the control.

The leaves on the first flush of growth were larger, those on the second slightly smaller, than the leaves on the controls. Increases in leaf size with other plants following treatments with gibberellin have been reported by Gray (1957) and Kribben (1957). Bract-like leaves developed at the first, second, and third nodes on the second flushes of growth (Fig. 3).

A slight chlorosis of the new foliage was evident late in the season on the second flush of growth.

Fig. 3. Gibberellin effects on shoot growth, leaf size, internode length, aesthetic value and fruiting of *Euonymus fortunei vegetus* (top) and *Forsythia "Arnold Dwarf"* (bottom). A and B—left to right, current season's shoot growth resulting from foliar sprays of 0, 10 single, 10 weekly, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. C and D—left, control (no treatment); right, 100 p.p.m. weekly of gibberellin. Note (C and D) that *Euonymus fortunei vegetus* and *Forsythia "Arnold Dwarf"* developed a more open habit, and formed more nodes and longer internodes as a result of treatment. In A and B bract like leaves developed on shoots sprayed weekly with 100 or once with 1,000 p.p.m. with the variation in leaf size apparently dependent on the time of initiation. New flushes of growth from otherwise dormant buds occurred in *Euonymus fortunei vegetus* sprayed once with 100 or 1,000 or weekly with 100 p.p.m. In C note that no fruit developed on the gibberellin treated plants. The initial application of gibberellin was in early May when the leaves were expanding. Photographed August 21, 1957.

Forsythia "Arnold Dwarf"

Three-year old plants, 15 to 18 inches in height, were selected. As with dwarf varieties of other plants treated with gibberellin (Barton, 1956; Brian and Hemming, 1955; Bukovac and Wittwer, 1956), significant differences were observed in total terminal growth and in some instances in the number of nodes (Table 1, Fig. 1, 2, 3).

In late June, terminal buds were formed on the controls and on those plants which received single or weekly treatments of 10 p.p.m. On the plants sprayed weekly with 100 or singly with 1,000 p.p.m., continuous growth occurred until mid-July when the terminal buds

formed. Plants sprayed weekly with 100 p.p.m. formed bract-like leaves, and death of many of the terminal meristems occurred. There was a reduction in the size of the leaves and an increase in internode length on the lower half of the new shoots, as compared to the controls. There was also a tendency for those plants receiving single applications of 10, 100, and 1,000 p.p.m. to have shorter internodes and larger leaves on the upper parts of the shoots (Fig. 3).

By June 25, the foliage of plants treated weekly with 10 or 100 p.p.m. of gibberellin was slightly chlorotic, but this was not severe until July 16. Plants sprayed once with 100 p.p.m. showed moderate to extreme chlorosis, whereas those treated with a single dosage of 10 p.p.m. exhibited only slight chlorosis. By September, the foliage of all plants, with the exception of those that received weekly applications of 100 p.p.m. was a normal green color.

Vicari Golden Privet (*Ligustrum obtusifolium vicari*)

Gibberellin treatment of 3-year old plants, 15 to 18 inches in height, resulted in significant increases in terminal growth, number of nodes, and number of fruit (Table 1, Fig. 1, 2, 4). By early June, differences in growth were obvious on plants sprayed weekly with 10 or 100 or singly with 100 or 1,000 p.p.m. Wilting of the new growth on plants receiving the above treatments was observed on June 12, but was no longer apparent after June 24.

By June 12, plants sprayed weekly with 10 or 100 and once with 100 or 1,000 p.p.m. formed loose and open flower heads. Flower buds died in many plants treated weekly with 100 p.p.m. The number of flower clusters per plant, however, was not significantly altered. With one exception, 10 p.p.m. weekly, there was a significant reduction in the number of fruit on all plants sprayed with gibberellin.

During the latter part of June, the terminal meristems of plants sprayed weekly with 10 or 100 p.p.m. and singly with 1,000 p.p.m. began to die. The terminal buds were initiated on all plants, including controls, during late June. A new flush of growth occurred during the first week of July, the magnitude of which differed greatly among the treatments (Fig. 1, 2, 4). A second terminal bud was initiated on all plants during the first week of September. Internode length was increased as shown in Fig. 2 and 4.

By July 3, all plants sprayed once with 100 or 1,000 p.p.m. or weekly with 100 p.p.m. were definitely chlorotic as compared to the controls or those sprayed once or repeatedly with 10 p.p.m.

Fig. 4. The effects of gibberellin on shoot growth, internode length, and aesthetic value of *Ligustrum obtusifolium vicari* (top) and *Prunus tomentosa* (bottom). A and B—left to right, current season's shoot growth resulting from foliar sprays of 0, 10 single, 10 weekly, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. C—left to right, growth responses following treatment with 0, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. D—left to right, 0, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. Note (C and D) the open habit resulting from an increase in the internode length and a loss of leaves in the gibberellin treated plants. *Prunus tomentosa* sprayed weekly with 100 p.p.m. appeared stunted as shown in D. A—leaves initiated early in the season on gibberellin treated plants were larger than those on the controls, but those formed later in the season tended to be smaller except on those plants sprayed singly with 100 and 1,000 p.p.m. Note abscission of leaves on shoots sprayed weekly with 10 or 100 or once with 1,000 p.p.m. *Prunus tomentosa* (B) sprayed once with 10, 100, or 1,000 p.p.m. or weekly with 10 p.p.m. showed an increase in leaf size as compared with the controls. Note dieback of shoots sprayed weekly with 100 p.p.m. Gibberellin was applied in early May during expansion of the first leaves. Photographed August 21, 1957.

Saucer Magnolia (*Magnolia soulangeana*)

Shoots of 3-year old plants, 12 to 18 inches in height, showed a marked increase in terminal growth (Table 1, Fig. 1), and internode length (Fig. 2, 5) when treated with gibberellin.

Differences in shoot growth were apparent by June 12. The terminal bud was initiated in all gibberellin treated plants during the third week of August. A week later, on all plants sprayed repeatedly

with 100 p.p.m., a flush of shoot growth occurred from 40 percent of the terminal buds.

Occasionally new flushes of growth occurred on plants which received a single application of 100 or 1,000 p.p.m., while all buds on the control plants and those sprayed once with 10 or repeatedly with 10 p.p.m. remained dormant (Fig. 1). All shoots that continued to grow through August initiated a second terminal bud by mid-September.

Leaf size was reduced on the shoots of all plants sprayed weekly with 10 or 100 or singly with 1,000 p.p.m. compared with the control. A single treatment with 10 p.p.m. gave an increase in leaf size (Fig. 5).

On July 16, plants sprayed once with 100 or 1,000 p.p.m., or weekly with 10 p.p.m. showed slight to moderate chlorosis while those sprayed weekly with 100 p.p.m. were moderately chlorotic.

Cork Tree (*Phellodendron amurense*)

Treatment of 2-year old plants, 10 to 12 inches in height, produced significant differences in the number of nodes, length of terminal growth (Table 1), and number of living shoots (Fig. 5).

Length of shoot growth of plants sprayed weekly with 100 p.p.m. totaled 45.0 centimeters as compared to 20.9 for the controls. Those plants sprayed once with 1,000, or repeatedly with 100 p.p.m. of gibberellin had fewer but longer shoots. By June 21, internode lengths of shoots were three to four times those of the controls on plants sprayed weekly with 100 p.p.m. and two to three times greater on plants that received a single application of 1,000 p.p.m.

Terminal buds had set by August 21 on all gibberellin treated plants with the exception of those sprayed once or weekly with 100 p.p.m. which set terminal buds 1 to 2 weeks later. Plants treated weekly with 10 or 100 p.p.m. formed terminal buds but later abscission of 20 and 40 percent, respectively, of these buds occurred. Terminal buds on all other plants were normal. The size of the individual leaves and leaflets was greatly reduced on all gibberellin treated plants (Fig. 5).

In early August leaf abscission occurred on the lower half of the current season's growth of all plants sprayed weekly with 100 and to a lesser extent with weekly applications of 10 p.p.m.

Plants treated weekly with 100 or once with 1,000 p.p.m. became very chlorotic by July 16. This chlorosis disappeared by September in plants that were sprayed once with 1,000 but not on those that received weekly applications of 100 p.p.m. of gibberellin. Leaves were a normal green color on all other plants.

Fig. 5. Comparative effects of gibberellin on shoot growth, node number, size of flowers and leaves, internode length, and aesthetic value of *Phellodendron amurense* (top), *Hydrangea arborescens grandiflora* (middle), and *Magnolia soulangeana* (bottom). A—left to right, variations in leaf size and shape resulting from 0, 10 single, 10 weekly, 100 single, 1,000 single, and 100 p.p.m. weekly applications of gibberellin. B and C—left to right, 0, 10 single, 10 weekly, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. D—left to right, 0, 1,000 single, and 100 p.p.m. weekly applications of gibberellin. E—left to right, 0, 10 single, and 10 p.p.m. weekly applications of gibberellin. F—left to right, 0, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. In D, E, and F note the increases in internode length, open growth habit, and increased shoot growth resulting from treatment with gibberellin; in E the increase in flower size of the middle plant; in A, B, and C the reduction of leaf size from repeated applications of gibberellin, and the increase in leaf size (B and C) from a single application of 10 p.p.m. Necrosis of leaves and slight chlorosis occurred (B and C) when plants were sprayed weekly with 10 and 100 p.p.m. Gibberellin was applied in early May during expansion of the first leaves. Photographed August 21, 1957.

Dwarf Red Leaf Barberry (*Berberis thunbergi "Crimson Pygmy"*)

Gibberellin treated 2-year old plants, 3 to 6 inches in height, showed significant increases in number of shoots and amount of new growth (Table 1, Fig. 6).

Plants treated repeatedly with 100 p.p.m. produced an average of 13.6 centimeters of new shoot growth as compared to 8.2 centimeters for the controls. Also, an average of 9.2 new shoots formed on the plants sprayed weekly with 100 p.p.m. of gibberellin compared to only 3.4 for the controls. Plants treated with 10 and 100 p.p.m. weekly, and singly with 100 and 1,000 p.p.m. showed increases in growth by June 6. However, by the first week of July, 70 to 90 percent of the shoots had died back 3 to 8 centimeters on plants sprayed weekly with 100 or singly with 1,000 p.p.m.

By contrast, death occurred on only 30 percent of the terminal meristems of the controls and those sprayed singly or repeatedly with 10 and once with 100 p.p.m. Slight to moderate leaf burn was evident during the latter part of August on plants sprayed with 10 or 100 weekly or with a single application of 1,000 p.p.m. (Fig. 6).

Axillary buds were stimulated to produce shoots. On plants sprayed weekly with 10 or 100 p.p.m., eight and 18 axillary buds, respectively, produced shoots, while buds on the plants of all other treatments remained dormant. Shoots that developed from axillary buds on plants sprayed weekly with 100 p.p.m. grew 7 to 20 centimeters. The tips of these shoots died back severely. Leaves on shoots produced from axillary buds resembled bracts (Fig. 6). Internode lengths of shoots developing from both terminal and axillary buds of plants treated with 10 and 100 p.p.m. weekly and once with 100 and 1,000 p.p.m. were greater than the controls.

Korean Little Leaf Boxwood (*Buxus microphylla koreana*)

One-year old plants, 3 to 6 inches in height, following treatment with gibberellin, exhibited no significant differences in any of the growth measurements but there were variations in the responses (Fig. 6). The variability in growth of shoots selected probably accounted for the lack of significance.

Differences in growth appeared during the first week of July. Plants sprayed once with 1,000 p.p.m. had only a few shoots on each plant which grew more than those on the controls, therefore, a very open habit of growth resulted. Single applications of 10 and 100 p.p.m. gave a more even growth response with all shoots. Thus, with

Fig. 6. Gibberellin applied as a foliar spray resulted in differences in total terminal growth and aesthetic value in (A) *Thuja hoveyi*, (B) *Syringa vulgaris violetta*, (C) *Buxus microphylla koreana*, and (D) *Berberis thunbergi "Crimson Pygmy"*. A and B—left to right, 0, 10 weekly, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. C and D—left to right, 0, 10 single, 10 weekly, 100 single, 100 weekly, and 1,000 p.p.m. single applications of gibberellin. Note loss of density and fine texture resulting from treatment and the increase in terminal growth in A. Gibberellin treated plants (B) showed a reduction in leaf size and an increase in internode length as compared to the control; note cupping of leaves in all plants sprayed with gibberellin. An increased internode length in C and D resulted from treatment with 10 weekly, 100, or 1,000 p.p.m. single applications of gibberellin and produced plants with an open habit. Note stunted growth (C) of plant sprayed weekly with 100 p.p.m. Ten or 100 p.p.m. of gibberellin sprayed on *Berberis thunbergi "Crimson Pygmy"* stimulated growth of shoots developing from axillary buds, which produced rudimentary leaves. Gibberellin initially applied during early May when the new leaves were expanding. Photographed August 21, 1957.

the latter treatments there was an increase in growth with only slight loss of aesthetic value.

Weekly applications of 100 p.p.m. produced three out of five plants that were stunted (Fig. 6). These plants had dark green leaves that were closely adpressed to a more rigid shoot than found in the controls. By contrast, two of the plants sprayed with 100 p.p.m. weekly showed great extention of the internodes and responded similarly to those which received a single application of 1,000 p.p.m.

Terminal buds were set on all plants the latter part of June. During the first week of July, 60, 70 and 80 percent, respectively, of the buds on plants treated singly or weekly with 10 or once with 1,000 p.p.m. commenced growth. New flushes of growth on plants subjected to the other treatments varied only slightly from the controls on which

20 percent of the buds showed activity. On those shoots which produced a second flush of growth, the terminal buds were formed the first week of August, except for plants sprayed with 1,000 p.p.m., which set terminal buds during the third to fourth week of August.

The axillary buds produced shoots on a few plants treated with single applications of 100 or 1,000 p.p.m. and weekly with 100 p.p.m. This was most noticeable on plants sprayed singly with 100 or 1,000 p.p.m. The axillary shoots grew 5 to 8 centimeters before the terminal bud was formed. The size of the leaves on the shoots that developed from the axillary buds was slightly less than on the control plants. The leaves that developed on shoots originating from the previous season's terminal buds were larger than those on the controls.

Chlorosis was not evident until late in the season, and then only on plants treated weekly with 10 p.p.m.

Hills of Snow (*Hydrangea arborescens grandiflora*)

With 2-year old plants, 15 to 18 inches in height, gibberellin produced significant differences in the numbers of aesthetic flowers produced. Weekly applications of 100 and a single treatment of 1,000 p.p.m. resulted in flower clusters that were extremely open in habit, contorted, and twisted. Those plants that received only a single treatment of 10 p.p.m. developed a larger flower than the controls, with no loss of aesthetic value (Fig. 5). The average width of the flowers was 9.2 centimeters compared to 7.3 for the controls. There were, however, fewer flowers on all plants treated with gibberellin. Premature browning of flower petals occurred on plants sprayed weekly with 100 or once with 1,000 p.p.m.

By June 21, an increase in growth resulting from longer internodes was observed on plants treated weekly with 10 or 100, and singly with 100 and 1,000 p.p.m. A reduction in leaf size and a lengthening of the petiole occurred on plants sprayed with 10 or 100 weekly or once with 1,000 p.p.m. Plants sprayed once with 10 p.p.m. had larger leaves than the controls.

Weekly sprays of 10 or 100 p.p.m. produced a spiral shoot growth (Fig. 5). By July 21, these plants and those given a single treatment of 1,000 p.p.m. had developed shoots from 90 percent of the axillary buds. Bract-like leaves were formed on the spindly axillary shoots which grew from 7 to 20 centimeters on plants sprayed weekly with 100 p.p.m. These plants lost all aesthetic value and were very "weedy".

Preceding the first week in August there was considerable dessi-

cation of the growing shoots on all gibberellin treated plants except with a single application of 10 p.p.m. It appeared that gibberellin had created a moisture stress. Many leaves eventually turned brown and abscissed, and those remaining exhibited severe tipburn. These effects were not as noticeable on plants sprayed once with 10 or 100 p.p.m. as when the treatments were repeated. No leaf burn occurred on the control plants.

At the end of the growing season, plants sprayed once with 1,000 p.p.m. were moderately chlorotic.

Manchu Cherry (*Prunus tomentosa*)

Difference in growth from treatment of 1-year old seedlings, 6 to 12 inches high, with gibberellin became apparent by June 21. Plants sprayed once with 10, 100 and 1,000 p.p.m. and weekly with 10 p.p.m. produced larger leaves as compared to the controls (Fig. 4). Leaves were less tomentose and thinner. Shoot growth was extremely variable, both within and between treatments, which resulted in no significant differences.

A significant reduction in node number and stem diameter (Fig. 4), however, occurred on seedlings sprayed weekly with 100 p.p.m. of gibberellin. These plants were stunted by July 1 and showed necrosis of the leaf tips and terminal meristems. There was also a reduction in leaf size (Fig. 4). By July 21, 80 percent of the terminal meristems had died.

Premature abscission of leaves occurred on plants sprayed weekly with 10 or 100 p.p.m. and from single applications of 100 or 1,000 p.p.m.

By July 1, a marked chlorosis occurred on plants sprayed weekly with 100 p.p.m., while those sprayed once with 100 or 1,000 p.p.m. or weekly with 10 p.p.m. were slightly to moderately chlorotic. Late in the season plants sprayed singly with 100 p.p.m. developed the greatest chlorosis of all treatments, while early in the season plants sprayed weekly with 100 p.p.m. were most chlorotic.

Lilac (*Syringa vulgaris violetta*)

Two-year old rooted cuttings showed no significant increases in growth following treatment with gibberellin. Increases in growth became apparent by June 21, but variations in response resulted in no significant differences. There was an increase in internode length,

and leaf size was reduced at the nodes near the apex as compared to the controls (Fig. 6).

Approximately three terminal buds formed in mid-June on the controls, while those treated weekly with 100 and once with 1,000 p.p.m. set only one per plant. The remaining terminal meristems died by June 14, whereas the buds that developed, set by June 21.

Japanese Yew (*Taxus cuspidata*)

Significant retardation of growth resulted when 3-year transplants, 4 to 8 inches in height, were sprayed with gibberellin. This reduction in growth was apparent by July 21 on all gibberellin treated plants except those given a single application of 10 p.p.m.

Terminal buds set July 15 on plants sprayed weekly with 10 and 100 p.p.m. while those sprayed once with either 10 or 1,000 p.p.m. set terminal buds during the first part of August. Terminal buds set during the first week of September on all controls. By August 8, plants sprayed weekly with 10 or 100 p.p.m. and once with 100 or 1,000 p.p.m. appeared retarded, as compared to the controls and those sprayed only once with 10 p.p.m.

American Arbor-vitae (*Thuja occidentalis hoveyi*)

Gibberellin applied to 2-year old plants, 6 to 10 inches in height, resulted in small but significant increases in terminal growth (Table 1). The internodes on plants sprayed weekly with 10 or 100 p.p.m. were extended, and the width of the leaves reduced (Fig. 6). This resulted in a loss of fine texture, and aesthetic value. On plants sprayed weekly with 100 p.p.m. considerable leaf abscission occurred following a browning of the main branches in early August. Chlorosis of the foilage was apparent in mid-July on plants sprayed weekly with 100 p.p.m.

Dwarf European Cranberry-bush (*Viburnum opulus nana*)

Again small but significant increases in terminal growth occurred on 2-year plants, 3 to 6 inches in height, following treatment with gibberellin (Table 1). All treated plants showed an increase in internode length when compared with the control. Weekly sprays of 100 p.p.m. resulted in shoots with smaller leaves and less prominent lobes. Other gibberellin treated plants produced leaves that were slightly larger than the controls.

Terminal buds set on all plants by July 1, except those treated weekly with 100 or once with 1,000 p.p.m. which set their buds 7 to 10 days earlier. Occasionally new flushes of growth from otherwise dormant buds occurred on plants sprayed weekly with 100 or once with 1,000 p.p.m. All plants treated with gibberellin were slightly chlorotic as compared to the controls.

SUMMARY AND CONCLUSIONS

Following foliar sprays of gibberellin, several woody ornamental plants showed marked stem elongation, an increase in node number, continuous growth of shoots, and a succession of growth flushes from otherwise dormant buds. Those which gave a positive response with little or no loss of aesthetic value included, *Euonymus fortunei vegetus, Forsythia "Arnold Dwarf", Ligustrum obtusifolium vicari, Magnolia soulangeana, Thuja occidentalis hoveyi,* and *Viburnum opulus nana. Berberis thunbergi "Crimson Pygmy",* and *Phellodendron amurense* exhibited a significant increase in growth at the expense of aesthetic value. *Buxus microphylla koreana, Hydrangea arborescens grandiflora, Prunus tomentosa,* and *Syringa vulgaris violetta* failed to show a significant increase in living terminal growth, while *Taxus cuspidata* was stunted when sprayed with gibberellin.

The increase in terminal growth and number of nodes following gibberellin treatment of *Forsythia "Arnold Dwarf"* and *Phellodendron amurense* resulted from an extended period of growth by a delay in the setting of the terminal bud. Similar responses from exposure of other woody species to long photoperiods have been reported by Nitsch, (1957a and 1957b).

In *Euonymus fortunei vegetus* and *Magnolia soulangeana,* however, increases in growth resulted from longer internodes and a succession of growth flushes from otherwise dormant buds. In *Thuja occidentalis hoveyi* and *Viburnum opulus nana,* there was an increase in terminal growth without a second growth flush and no increase in node number. *Berberis thunbergi "Crimson Pygmy"* showed increased growth from activation of axillary buds. With *Ligustrum obtusifolium vicari* the increase in terminal growth resulted from more nodes and longer internodes. Gibberellin treated *Taxus cuspidata* set terminal buds earlier than the controls, thus producing plants of a stunted appearance. It appears that a great variety of growth responses may be produced on woody plants with gibberellin, and the extent to which it

will replace the effects of a long photoperiod varies with the species (Lockhart and Bonner, 1957).

The growth of shoots was greatest on all plants which responded to gibberellin during normal vegetative extension in the spring. However, if a second flush occurred, the increase in growth was greatest following the normal growing period as illustrated by *Euonymus fortunei vegetus* (Fig. 1).

Plants sprayed weekly with 10 or 100 or once with 1,000 p.p.m., generally showed a reduction in leaf size as compared to the controls. Those plants producing successive flushes of growth developed larger leaves on the first growth and smaller leaves on the second, as compared to the controls as shown by *Ligustrum obtusifolium vicari* (Fig. 4). Plants sprayed once with 10 p.p.m. generally showed an increase in leaf size compared to the controls. Suggested treatments for maximum growth as well as the accompanying deleterious effects are summarized in Table 2.

Some favorable or potential uses for gibberellin on woody ornamental plants as suggested by these studies include: (a) increase in terminal growth with no loss of aesthetic value (the possibility of

TABLE 2—Gibberellin effects on certain woody ornamental plants—summary of observations

Woody ornamental plants	Spray treatment for maximum growth (p.p.m.)	Spray treatment for maximum growth and aesthetic value (p.p.m.)	Undesirable or deleterious effects
Euonymus fortunei vegetus	100 weekly	100 weekly	Leaves slightly smaller; no fruit; reduction in total number of shoots.
Forsythia "Arnold Dwarf"	100 weekly	10 weekly or 100 single	Leaves very small; leaf and shoot tips died back slightly at 100 p.p.m. weekly; round habit lost from extended growth; moderate chlorosis.
Ligustrum obtusifolium vicari	100 weekly	1,000 single	Little to no fruit; leaf abscission at 2-4 nodes in succession; small lanceolate leaves on continued growth at 100 p.p.m.; moderate chlorosis.
Magnolia soulangeana	1,000 single	100 single	None at 100 p.p.m. single, but 1,000 p.p.m. single had leaf abscission at 2-3 nodes in succession; leaves slightly smaller; slight chlorosis.

TABLE 2—Concluded

Woody ornamental plants	Spray treatment for maximum growth (p.p.m.)	Spray treatment for maximum growth and aesthetic value (p.p.m.)	Undesirable or deleterious effects
Phellodendron amurense	100 weekly	10 weekly or 100 single	None at 10 p.p.m. weekly, but at 100 p.p.m. weekly leaf size was greatly reduced and internodes greatly extended; some leaf abscission on lower part of plant; abscission of terminal buds; moderate chlorosis.
Berberis thunbergi "Crimson Pygmy"	100 weekly	10 single	None at 10 p.p.m. single, but 100 p.p.m. weekly had meristems that died; tended to be "leggy".
Buxus microphylla koreana	1,000 single	10 single	None at 10 p.p.m. single, but 1,000 p.p.m. single had extended internodes and an open habit; slight chlorosis.
Hydrangea arborescens grandiflora	100 weekly	10 single	None at 10 p.p.m. single, but 100 p.p.m. weekly had an open habit, smaller leaves, elongated petioles, general overall leaf abscission, shoots developed from axillary buds, shoots died back, and a spiral-like growth.
Prunus tomentosa	100 single	10 single	Slightly open habit from leaf abscission.
Syringa vulgaris violetta	100 single	100 single	Slightly open habit; smaller leaves at nodes near apex.
Taxus cuspidata	control	control	None
Thuja occidentalis hoveyi	100 weekly	100 single	None at 100 p.p.m. single, but 100 p.p.m. weekly had elongated leaves and a slightly open habit.
Viburnum opulus nana	100 weekly	100 single	None at 100 p.p.m. single, but 100 p.p.m. weekly had elongated leaves and a slightly open habit.

2 years growth in 1); (b) increase in terminal growth with loss of aesthetic value (this may be useful to the nurseryman who is interested in "growing on stock"); (c) combination of a gibberellin spray program with pruning for promoting shoot growth from axillary buds thus developing a dense, compact plant in less time; (d) death of terminal

meristems to eliminate pruning in some plants; (e) promotion of growth rates in dwarf varieties to a desirable size; (f) abscission or dessication of flowers on plants which produce obnoxious fruit; and (g) increase of flower size in some species.

It may be concluded that treatment of woody ornamental plants with gibberellin may be useful to the nurseryman and homeowner if certain cultural practices are altered. These might include the use of more fertilizer and water to compensate for the increased growth rates which are often accompanied by slight to moderate chlorosis of the foliage, and wilting and dieback of leaves and shoots.

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JOURNAL ARTICLE ABSTRACTS

A Rapid Method for the Detection of Colonies of *Listeria monocytogenes*

GRAY, M. L.

Zentralblatt für Bakteriologie, I. Orig. 169:373-377. 1957. (Journal Article 1726 from the Michigan Agricultural Experiment Station)

By means of a binocular scanning microscope and obliquely transmitted light it is possible to readily distinguish colonies of *Listeria monocytogenes* when grown on tryptose agar plates. After 24 hours incubation at 37°C the colonies are round, with a slightly raised finely textured surface, and an entire margin. They are translucent, blue-green in color, and watery in consistency. The need for maceration and possibly refrigeration of tissues or body fluids suspected of containing *L. monocytogenes* is stressed, since this greatly enhances the probability of isolating the bacterium.

Notes on the Inheritance of White Laced Red of Cornish

HENDERSON, E. W.

Poul. Sci. 35:13-16. 1956. (Journal Article 1773 from the Michigan Agricultural Experiment Station)

Color varieties of pure Standard Cornish have not included Silver which would permit autosexing of chicks. The appearance of Silver bars in the F_2 of a Cornish-White Leghorn cross at the Michigan Agricultural Experimental Station in 1947 suggested crosses with Standard White or White Laced Red and Dark Cornish which resulted in a Silver barred strain and subsequently a Silver Laced strain. Tentative genetic explanations are postulated and slight revisions of genetic theories are suggested.

The Effect of Potassium N-1-naphthylphthalamate on the Geotropic Response and Growth of Corn, Pea, and Oat Seedlings

CHING, TE-MAY TSOU; R. H. HAMILTON; R. S. BANDURSKI; B. H. GRIGSBY AND G. B. WILSON

NC Weed Control Conf. (Abstracts). 1955. (Journal Article 1855 from the Michigan Agricultural Experiment Station)

Potassium N-1-naphthylphthalamate inhibits the geotropic response and straight growth of both shoots and roots of corn and pea seedlings. Each kind of inhibition is proportional to the concentration of the chemical used for treatment. It is of interest, however, that concentrations which abolish the geotropic response do not greatly reduce straight growth. Complete inhibition of straight growth requires much higher concentrations than are required for complete inhibition of geotropic curvature. This selective inhibition is not due to direct antagonism of Auxin action. The mechanism by means of which potassium N-1-naphthylphthalamate causes this selective inhibition remains unknown. Elucidation of this mechanism should provide information regarding the plant's internal regulation of differential growth responses.

Benthic Productivity as Influenced by Fish Predation

HAYNE, D. W. AND R. C. BALL

Limnology and Oceanography 1:162-175. 1956. (Journal Article 1861 from the Michigan Agricultural Experiment Station)

Sampling of benthic organisms was carried out in two similar, one-acre ponds in southern Michigan throughout the open water period of 1951. Fish were present in one of the ponds the first half of the summer and were transferred to the second pond in early July. Rates of growth of the fish and the bottom organisms were estimated and the production calculated at both trophic levels. Calculated production of 811 pounds of fish-food and 181 pounds of fish are shown to be of reasonable order as compared with other studies. In the absence of fish, the apparent production rate of fish food decreased and finally stopped at a higher level of standing crop. In the presence of fish, the standing crop of fish food was depressed and the rate of production increased.

Nutrient Uptake, with Special Reference to Foliar Absorption

WITTWER, S. H.

Atomic Energy and Agriculture, Am. Assoc. for the Advancement of Sci. 1957. (Journal Article 1871 from the Michigan Agricultural Experiment Station)

Radioisotopes permit tracing the path of nutrients in plants when they are applied as sprays to leaves, stems, and fruits. P^{32}, K^{42}, S^{35} and N^{15} are taken up by all aerial plant tissues. Basipetal and acropetal transport to all other plant parts is rapid. A high percentage (40 to 95 percent) of the applied nutrient is often absorbed within a few days or even hours. Significant contributions to the total nutritional needs of plants may be made following a single spray. In contrast Ca^{45}, Sr^{89}, Sr^{90}, Ba^{140}, Fe^{55} and Ru^{103}, while readily absorbed by leaves and fruit, move little if at all from the above ground absorbing organ.

The absorption of nutrients from sprays is favored by high humidity, temperature, incident radiation, a carbohydrate supply, and vigorous growth. Carrier ions, pH, and surface active agents also exert a great influence. Radioactive minerals are not only taken up from foliage sprays but when absorbed by roots or through cut stems, they may be lost from the leaves during rainfall. Foliar absorption likely involves the passage of nutrients through discontinuities in the cuticle. The epidermal plasmodesma are the most probable entry sites.

Effect of Moisture and Fertilization on Emergence of Sugar Beet Seedlings

SNYDER, F. W.

Jour. of the Am. Soc. Sugar Beet Tech. 9:450-456. 1957. (Journal Article 1881 from the Michigan Agricultural Experiment Station)

The effects of controlled soil moisture and specific fertilization practices on emergence of the sugar beet were determined in the laboratory at 20°C. ± 2°.

1. For a given fertilizer rate and placement, as the soil moisture level was decreased, emergence was progressively delayed. There was a substantially lower percentage of emergence at the lower moisture levels.

2. Banding 100 pounds per acre (28-inch rows) of 10-10-10 fertilizer in contact with the seed at 14.7 percent soil moisture resulted in emergence of less than 50 percent of the potential stand in 20 days.

3. Emergence was substantially delayed when seeds were placed ½ inch above the band of fertilizer as compared with seeds placed 1 inch to the side and ½ inch above the fertilizer.

4. At the same rate of application in contact with the seeds, 0-20-10 delayed emergence least, 0-10-20 was intermediate, and 10-10-10 delayed emergence most. This was correlated with solubility of the fertilizers.

5. It is recommended that fertilizer be placed away from the sugar beet seeds to avoid delays in emergence at the lower soil moisture levels.

Economics of High Quality Forage and Dairy Feeding

HOGLUND, C. R.

Proc. 14th Internat. Dairy Conf. 1:1-14. 1957. (Journal Article 1887 from the Michigan Agricultural Experiment Station)

Michigan dairymen can increase net returns by as much at $14 to $20 per cow by feeding excellent rather than poor quality roughage. The more successful dairy farmers are producing 10,000 pounds of 3.5 test milk with 2,000 pounds or less of farm grain.

A stand high in legumes is a necessary requirement for the production of high quality roughage under climatic conditions existing in Michigan and other Great Lakes states. It is difficult to harvest high quality roughages unless they are harvested for grass silage or barn-dried hay.

Dairymen must invest from $1,700 to $2,800 more in harvesting equipment and in silage storage when they shift from field-cured, baled hay to the production of grass silage or barn-dried hay. These investments are most profitable if dairy farmers have at least 20 cows.

Selective Inhibition of the Geotropic Response by N-1-naphthylphthalamic Acid

CHING, TE-MAY; R. H. HAMILTON AND R. S. BANDURSKI

Physiologia Plantarum 9:546-558. 1956. (Journal Article 1888 from the Michigan Agricultural Experiment Station)

A quantitative study was conducted to examine the selective inhibition of geotropic response in plants by N-1-naphthylphthalamic acid (NP). The following results were obtained:

1. Over the time interval for geotrophic bending to reach a maximum, a direct correlation between the rate of straight growth and geotrophic curvature exists in untreated Avena coleoptiles and the young roots and shoots of corn and peas.

2. A disproportional inhibition of growth and curvature was found in NP-treated roots and shoots of corn and peas, but no disproportionality was observed in NP-treated Avena coleoptiles.

3. Corn roots treated with 2,4-dichlorophenoxyisobutyric acid showed a proportional inhibition of straight growth and geotropic curvature.

4. The disproportional inhibition induced by NP seems not accountable for by the Went-Cholodny theory of geotropism.

The Effect of Dietary Lactose on the Intestinal Transit and Skeletal Retention of Radioactive Strontium^{90}-Yttrium^{90} in the Chick

THORNTON, P. A.; P. J. SCHAIBLE AND L. F. WOLTERINK

Poul. Sci. 35:1055-1060. 1956. (Journal Article 1889 from the Michigan Agricultural Experiment Station)

The passage rate of Sr^{90}–Y^{90} from the upper portion of the digestive tract (esophagus, crop, proventriculus, and ventriculus) has been determined in 2-week old chickens on two different feeding regimes.

Following injection into the crop, about one-third of the isotope left the upper portion of the digestive tract by 7.5 minutes. Movement of the remaining isotope occurred at a simple exponential rate which was highly correlated with time.

Deposition of Sr^{90}–Y^{90} in the skeleton was also measured and found to be highly correlated with the amount passed to the absorptive part of the intestines. It was unrelated to the concentration of the isotope in the blood which was very low at all times.

The addition of 25 percent C. P. lactose to the ration had no effect on the transit rate of Sr^{90}–Y^{90} from the upper gut despite the fact that its presence created an extremely watery excreta.

Colonial Dissociation of *Listeria monocytogenes*

GRAY, M. L.; H. J. STAFSETH AND FRANK THORP, JR.

Zentralblatt für Bakeriologie, I. Orig. 169:378-391. 1957. (Journal Article 1892 from the Michigan Agricultural Experiment Station)

Twenty different colonial forms of *Listeria monocytogenes* could be detected by means of obliquely transmitted light and a binocular scanning microscope. One of these was the naturally occurring smooth form found in isolations from infected human or animal tissue. This was characterized by a small, circular, slightly raised, finely textured, translucent, blue-green colony with an entire margin. It gave rise either directly or indirectly to the remaining 19 types designated as rough. They were characterized by a variety of colonial forms which differed in texture, consistency, configuration, opacity, or color from the smooth type. Only the smooth, two intermediate and one rough form, were pathogenic for rabbits when inoculated intravenously, subcutaneously, or instilled into the conjunctival sac. However, non-pathogenic forms produced a marked monocytosis in rabbits following intravenous or subcutaneous exposure. Six of the 19 rough forms could be maintained in stable form.

The Influence of Environment and Processing on Spoilage Organisms in Cottage Cheese

HARMON, L. G. AND C. K. SMITH

Jour. Milk and Food Tech. 19:252-259. (Journal Article 1904 from the Michigan Agricultural Experiment Station)

Microbiological analyses were performed on samples taken at various stages of processing of 17 vats of cottage cheese manufactured in 12 commercial plants. In 10 vats of fresh cheese whose shelf-life ranged from 5 to 10 days, the logarithmic averages of the counts of coliform, lipolytic, and proteolytic bacteria were 50, 1,298 and 1,967 percent greater than the corresponding averages of 7 vats

whose shelf-life ranged from 13 to 16 days. Spoilage organisms were found in water, coagulator, starter, air, contaminated equipment, and improperly pasteurized milk and cream. Several water supplies contained high populations of lipolytic and proteolytic organisms, but were free of coliform bacteria which are commonly used as an index of acceptability of water supplies.

Factors Influencing Phenotypic Expression of Cytoplasmic Male-Sterility in the Sugar Beet *(Beta vulgaris L.)*

HOGABOAM, G. J.

Jour. Am. Soc. Sugar Beet Tech. 9:457-465. 1957. (Journal Article 1907 from the Michigan Agricultural Experiment Station)

Sugar beet plants which have male-sterile cytoplasm (S) and contain a pollen restorer gene in the heteroxygous condition *(Xx)* were found to be variable in their phenotypic expression.

A new gene locus *(sh)* was discovered. When present in the dominant condition the *Sh* gene complements the pollen-restoring action of the heteroxygous *Xx* genotypes to the extent that there will be at least enough yellow color and fullness on the anthers that the plants would not be mistaken for the white anthered phenotypes which the homozygous recessive, *xx*, genotypes produce in male-sterile cytoplasm excluding other pollen restorer genes. The *Sh* gene is only a complementary gene, however, since it has no pollen restoring action of itself.

Studies of linkage relationships of the *X* pollen restorer gene suggest either linkage, with approximately 37 percent crossover, exists with the monogerm locus *(m)* or there is pleiotropic action of the monogerm gene in the recessive *(mm)* genotypes.

The Relationship of Stand to Panicles Per Plant and Per Unit Area in Oats

GRAFIUS, J. E.

Agronomy Jour. 48:460-462. 1956. (Journal Article 1916 from the Michigan Agricultural Experiment Station)

In this paper the relationship of panicles per unit area and panicle size to yield was shown. However, the major effort was devoted to determining the relationship of stand to panicles per plant and per unit area, and to express this relationship by means of two theorems.

Theorem I showed that $v = c10^{ku}$ where v = panicles per plant, u = plants per unit area and k = a varietal constant.

Theorem II showed that if the number of panicles per unit area (X) was equal to w then the maximum number of heads occurred when $u = b$ or $u = \frac{1^1}{2.3} k$, whichever was smaller over the region $a \leq u \leq b$.

The conclusions from both theorems were checked against field data for 40 varieties of oats.

Many of the empirical results of rate of seeding tests are in agreement with the theoretical findings. In general, rather wide variations in seeding rates around the optimum, produce only minor variations in yield.

[1]This is $u = \frac{1}{2.3K}$

Separation of Egg Yolk Proteins by Paper Electrophoresis

EVANS, R. J. AND S. L. BANDEMER

Jour. of Agr. and Food Chem. 5:868-872. 1957. (Journal Article 1929 from the Michigan Agricultural Experiment Station)

Proteins of whole unextracted egg yolk were separated from each other by the ridgepole paper electrophoresis technique of Durrum using a pH 8.6 diethylbarbiturate buffer of 0.05 ionic strength. The proteins were dyed with bromophenol blue and the lipides with Oil Red O. The protein color was eluted with dilute sodium hydroxide solution for quantitative studies and absorbency was determined at 590 mu in the spectrophotometer.

Fresh egg yolk protein contained 8.6 percent livetin, 41.7 percent lipovitellenin, 46.4 percent lipovitellin, and 3.3 percent of other proteins. Extraction with ether changed the electrophoretic behavior of the proteins so that lipovitellenin was not separated from lipovitellin, probably because part of the lipide is linked to lipovitellenin by a bond that is easily broken by contact with ether even in the cold.

Estimating the Thyroid Activity of Dairy Heifers

LODGE, J. R.; R. C. LEWIS AND E. P. REINEKE

Jour. Dairy Sci. 40:209-215. 1957. (Journal Article 1935 from the Michigan Agricultural Experiment Station)

The daily thyroxine secretion rate of intact dairy calves was estimated by a substitution technique in which the thyroid gland was progressively inhibited by administered l-thyroxine. This paper describes the technique employed.

The 48 hour uptake of tracer amounts of I^{131} (30 to 150 microcuries) injected subcutaneously averaged 41.6 percent of the administered dose for 63 calves representing all of the major dairy breeds. Although the uptake varied between individual animals and trials, the Brown Swiss heifers showed a comparatively lower uptake than the other breeds.

Due to an apparent recycling of the administered I^{131}, which was not prevented by subcutaneous administration of potassium iodide during the experimental period, it was necessary to give an oral dose of thiouracil at the rate of 0.2 grams per kilogram of body weight daily to prevent this recycling.

The daily thyroxine secretion rate of 13 calves ranged from 0.47 to 0.84 milligrams per 100 pounds of body weight.

Comparison of Phosphate Carriers for Oats and Hay on Certain Podsolized Soils of Eastern Canada

FINN, B. J.; R. L. COOK AND C. M. HARRISON

Agronomy Jour. 49:465-468. 1957. (Journal Article 1939 from the Michigan Agricultural Experiment Station)

In a greenhouse experiment two rock phosphates were compared with superphosphate. Oats and an alfalfa-timothy mixture were grown on three soils common to eastern Quebec.

Certain plant characteristics of the grain crop showed definitely more improvement with superphosphate treatment than with either of the rock phosphates.

Superphosphated soils produced yields of oats, grain, and straw which, in 85 percent of the comparisons, were significantly greater than those obtained where rock phosphates were applied. On all soils, superphosphate plus lime, proved significantly better in increasing grain and straw yields than did superphosphate alone. The addition of lime failed to produce significant increases in oat yields where rock phosphate was the source of phosphorus.

Rock phosphates proved definitely superior to superphosphate in increasing the yields of alfalfa-timothy tops and roots.

In the production of this crop on the more acid soils which were phosphated, lime significantly increased yields. However, on the least acid soil (pH 6.6), lime increased alfalfa yields in only one case, and that, strangely, was where the Hyperphosphate was applied with 1 ton of lime. When superphosphate and Hyperphosphate were the sources of phosphorus, the yields were depressed by the heavy lime application. Where the aerophos was used, both applications of lime depressed yields.

A Survey of Michigan Ice Cream at the Retail Level III. Microbiological Populations

MEISER, J. A. AND L. G. HARMON

Ice Cream Field 68:158-160. 1956. (Journal Article 1946 from the Michigan Agricultural Experiment Station)

One hundred and ninety-four pint samples of vanilla, chocolate, and strawberry ice creams were purchased in 73 stores located in Michigan. Samples were analyzed for total microbiological populations and coliform organisms.

Logarithmic averages of total counts on chocolate and strawberry ice creams were 100 percent greater than corresponding counts on vanilla.

Forty-six percent of vanilla, 54 percent of chocolate and 44 percent of strawberry purchases contained 10 or less coliform organisms per gram.

Forty percent of vanilla, 46 percent of chocolate, and 37 percent of strawberry samples did not exceed a 50,000 total count and 10 coliforms per gram.

Statistical analyses indicated a positive correlation significant at the 1 percent level between total microbiological populations and the number of coliform organisms in ice cream.

The data indicate a need for continued effort on the part of the manufacturer to improve the microbiological quality of Michigan ice cream.

Is Your Bulk Tank Accurate?

GILLETTE, A. K. AND C. W. HALL

Hoard's Dairyman 101:1119-1146, 1147. 1956. (Journal Article 1950 from the Michigan Agricultural Experiment Station)

The bulk milk tank is a measuring device as well as a cooler and storage container. In order to accurately measure milk quantity, certain precautions must be observed when installing and using the bulk tank: (1) the tank must be accurately calibrated at the factory; (2) the conversion chart must be correctly prepared; (3) the tank must be installed in the milkhouse in exactly the same position that it was in while being calibrated, and must not shift from this correct level during every day use, and (4) the measuring operation must be carefully performed in order to obtain an accurate milk line on the graduated rod.

Failure to observe any or all of these precautions will result in measuring error and a loss to the producer or dairy plant.

Effect of N-Arylphthalamic Acids on Tomato Flower Formation

TEUBNER, F. G. AND S. H. WITTWER

Am. Soc. for Hort. Sci. 69:343-351. 1957. (Journal Article 1952 from the Michigan Agricultural Experiment Station)

N-m-tolylphthalamic and other n-arylphthalamic acids when applied as foliage sprays to tomato plants during flower formation, specifically induce greater numbers of flowers to form. Activity of the N-arylphthalamic acids is related to their structure and apparently conditional upon no substituents in the position para to the nitrogen. The flower-forming stimulus of single or multiple applications appears to be independent of variety. Its effectiveness on an individual flower cluster is related to the developmental stage of the plant when treated. The extreme lability of the N-arylphthalamic acids offers a possible explanation for the fact that the flower forming effects are not accompanied by growth inhibition or formative effects.

Comparative Absorption and Utilization by Beans and Tomatoes of Phosphorus Applied to the Soil and Foliage

WITTWER, S. H.; F. G. TEUBNER AND W. W. MCCALL

Am. Soc. for Hort. Sci. 69:302-308. 1957. (Journal Article 1955 from the Michigan Agricultural Experiment Station)

The comparative absorption and utilization of P^{32}, labeled phosphoric acid, applied as a band in the soil or to the foliage of bean and tomato plants grown in pot cultures in the greenhouse was evaluated. Sand, clay, and organic soil types with, and without, their phosphate-fixing capacities saturated were utilized.

Approximately 10 times as much labeled phosphate was applied to the soil as adhered to the foliage. It was established that the amount of phosphate retained from foliage applications was a function of the dry weight of the tops. Measurements of efficiency of uptake from the foliage and the soil were accomplished by determining the recovery of applied phosphate in the developing fruits during an interval of three weeks.

Mean values for micrograms of phosphorus and percent of total phosphorus in the fruits derived from foliar treatments were more than double those for soil

applications. Efficiency of utilization, as measured by the percent of applied phosphorus recovered in the fruit was approximately 20 times greater for the foliar applications. The most pronounced differences occurred with crops grown on the sandy soil. Certain limitations in the interpretation of the results are recognized and discussed.

Possible Models for Agronomic-Economic Research

HILDRETH, CLIFFORD

Fertilizer Innovations and Resource Use (Chap. 16); 176-186. 1957. (Journal Article 1975 from the Michigan Agricultural Experiment Station)

Problems of incorporating additional variables such as weather measurements and results of soil tests into statistical analyses are discussed in general terms. Possible procedures for allowing for plant nutrients already in the soil when studying fertilizer response are outlined in more detail. Some methods of estimation are developed which are based on the assumption that total effective nutrient can be regarded as a weighted sum of nutrient added by the farmer or experimenter and available nutrient already in the soil as revealed by soil tests.

Some Problems and Possibilities of Farm Programming

HILDRETH, CLIFFORD

Fertilizer Innovations and Resource Use (Chap. 20) pp. 243-260. 1957. (Journal Article 1976 from the Michigan Agricultural Experiment Station)

Since the formal steps in solving a linear programming problem are routine and subject to fairly complete checks, the practical reliability of a solution depends mainly upon how well the investigator has succeeded in representing a practical problem in his programming model. In applying programming to the search for profitable farm production adjustments, agricultural economists have been hampered by the incompleteness of the production data ordinarily available and the fact that many commodity prices are variable and uncertain.

Concerted joint efforts of economists and technical agricultural scientists are needed to meet this problem but they are unlikely to eliminate it. For this reason it is desirable to devise programming constructions which show optimal adjustments for a variety of combinations of market prices and technical possibilities. A few such constructions have been developed and procedures for obtaining them are outlined.

Control of Magnesium Deficiency in Utah 10B Celery Grown on Organic Soil

JOHNSON, K. E. E.; J. F. DAVIS AND E. J. BENNE

Soil Sci. Soc. of Am. Proc. 21:528-532. 1957. (Journal Article 1985 from the Michigan Agricultural Experiment Station)

Observations were made over a 2-year period on the effects of applying varying quantities of compounds of magnesium, potassium, and sodium to organic soils to control magnesium deficiency in Utah 10B celery. The results showed that the occurrence of magnesium deficiency and the composition of the crop could be influenced by applications of potassium and sodium to the soil.

Soil applications of 2 to 4 tons of magnesium sulfate per acre were required to control the deficiency symptoms. Effective control was obtained by applying 7 pounds of magnesium sulfate per acre in 100 to 150 gallons of water as a weekly foliar spray throughout the growing season, starting 4 weeks after transplanting. This could be incorporated into the normal spraying schedule for disease and insect control.

The incidence of magnesium deficiency symptoms was inversely related to the percentage of magnesium in the plant. These symptoms were reduced to a minimum when the exchangeable calcium to magnesium ratio in the soil was less than 3:1 and when the magnesium saturation of the exchange complex was greater than 22 percent.

The Pyridoxine Requirement of the Baby Pig

MILLER, E. R.; D. A. SCHMIDT; J. A. HOEFER AND R. W. LUECKE

Jour. of Nutr. 62:407-420. 1957. (Journal Article 2017 from the Michigan Agricultural Experiment Station)

Levels of pyridoxine supplementation constituting 0, 0.5, 0.75, 1.0, and 2.0 milligrams per kilogram of solids in a synthetic milk diet were used to determine the pig's requirement of this vitamin. An analysis of the growth and feed consumption data indicates that the 0.5 milligram level is nearly adequate. However, data obtained on blood hemoglobin, red blood cell and lymphocyte counts, and urine xanthurenic acid excretion are presented which indicate that the minimum requirement, when a more nearly total consideration of the pig's well-being is given, lies between 0.75 and 1.0 milligrams of pyridoxine per kilogram of solids.

Classical deficiency symptoms were observed in those pigs receiving no pyridoxine. The performance of pair fed controls indicated that the effects on the blood and urine components found in deficient pigs were specific effects of pyridoxine deficiency and not effects of the resulting inanition.

Serum total protein values were not effected by pyridoxine deficiency but the relative values of certain serum protein fractions were altered. Evidence of renal and adrenal hypertrophy are presented. Therapeutic treatment of pyridoxine deficient pigs brought rapid recovery.

Factors that Promote the Growth of *Brucella* in the Presence of Blood

HUDDLESON, I. F.

Bulletin of the World Health Organization 16:929-938. 1957. (Journal Article 2023 from the Michigan Agricultural Experiment Station)

The data presented shows that the growth of *Brucella* cells in a mixture of culture medium (peptone type) and blood is not due to growth-promoting constituents in the medium. Rather, it is due to the presence of an agent or agents that inactivate the bacterial growth-inhibiting factor usually present in normal blood. The blood then becomes an excellent culture medium.

Rapid growth of all types and species of *Brucella* was obtained in cow, human, and horse blood alone by the addition of a cation exchange resin (H+).

If conditions are created in a closed container (bottle), so that CO_2 is released from the $NaHCO_3$ normally present in blood, other measures, such as the artificial addition of CO_2, are rendered unnecessary in any procedure for the growth of CO_2-dependent strains of *Brucella abortus* in the presence of blood.

Recent studies have shown that the correct amount of Duolite C-3H+ in blood promotes rapid growth of Gram-negative bacteria when present by removing other cations normally found in blood. These appear to be essential for the action of the bacterial-growth inhibiting mechanism in blood.

Growth of either Gram-negative or Gram-positive bacteria in blood may be accomplished by adding to the proper amount of Duolite C-3H+ (say 0.4 gram 0.05 gram of Duolite C-3Mg++).

Studies on the Occurrence of Pink Whites and Salmon Colored Yolks in Stored Eggs from Hens Fed Crude Cottonseed Oil or Cottonseed Meal

EVANS, R. J.; S. L. BANDEMER; J. A. DAVIDSON AND P. J. SCHAIBLE

Poul. Sci. 36:798-807. 1957. (Journal Article 2030 from the Michigan Agricultural Experiment Station)

Hens fed rations containing 2.5 percent of crude cottonseed oil produced eggs that after 6 months of cold storage had pink colored whites and enlarged salmon colored yolks. Some pink discoloration of the whites occurred in eggs from hens fed cottonseed meal, but olive yolk discoloration was more common. Carotene at levels of 2 or 4 grams, vitamin A acetate at levels of 4 or 8 million units, ferric chloride at levels of 23 or 46 grams, or iodine at a level of 10 grams per 100 pounds of mash did not consistently reduce the incidence of pink whites or salmon yolks.

Removal of the soapstock from crude cottonseed oil did not reduce the incidence of discolored eggs, although the soapstock removed caused some. Neither commercial soapstock nor the acidulated soapstock produced any pink white discoloration but did produce some olive yolks. Part of the olive yolk factor was extracted with ether. The factor causing pink whites was not extracted with alcohol, but it was destroyed by the heat needed for vacuum distillation.

Biologic Measurement of Environment as an Aid in Selection

GRAFIUS, J. E.

Agronomy Jour. 49:506-508. 1957. (Journal Article 2032 from the Michigan Agricultural Experiment Station)

Two models for classifying environment using standard varieties as a biologic measure were proposed. On the basis of the assumed models various schemes for selection were discussed. It was shown that it was not always advantageous to save the best lines. This paradox becomes less incredible when for example, one considers that if a variety performs well at cool temperatures relative to another, the reverse may be true at high temperatures. Hence, strains selected during an unusually cool season may be entirely out of place during the usual hot season.

The use of group theory to classify broad spectra of genotypes relative to given environmental variables appears both desirable and possible. In general, those one-to-one transformations of any set of elements which preserve any given property of these elements form a group. In this case, the property preserved is the position of each genotype on a line as it is rotated in a plane about the mean. Presumably one such group would be all the varieties that are elements of the Garry-Clintland set. The environmental variable is thought to be night temperature. When the relative yield positions of Garry and Clintland are known,

it is possible to predict the relative positions for all elements of a set over a wide range of night temperatures.

The Use of Antibiotics in the Making of Silage

DEXTER, S. T.

Agronomy Jour. 49:483-485. 1957. (Journal Article 2038 from the Michigan Agricultural Experiment Station)

Chopped alfalfa treated with antibiotics was placed in quart jars, sewer tiles, a bunker silo, and a stack and allowed to ferment into silage, in 1954, 1955, and 1956. After various intervals, the silages were examined for acidity and odor. The antibiotics streptomycin, aureomycin, penicillin, neomycin, bacitracin, terramycin, and mixtures of these were used in rates ranging from ½ to 200 parts by weight of antibiotic to a million parts of silage. In 1954, fermentation was greatly inhibited in the first few days by all treatments. Several months later, an improved quality was found in the case of streptomycin, aureomycin, and bacitracin silages. In 1955, all silages fermented equally, and no advantage was seen, either in jars, pile, or stack. In 1956, no advantage was noted. Sorbic acid preparations inhibited molding slightly. No recommendations can be made concerning the use of antibiotics in silage preservation.

Acorn Production on Good, Medium, and Poor Oak Sites in Southern Michigan

GYSEL, L. W.

Jour. of Forestry 55:570-574. 1957. (Journal Article 2045 from the Michigan Agricultural Experiment Station)

The number of black oak acorns on the medium and poor sites was approximately double that of red oak on the good site. On a weight basis, however, the red oak was approximately one-third more productive than the black oak. The number and weight of white oak acorns on good and medium sites was relatively small. The proportion of sound acorns varied from 24 percent to 52 percent; the greatest amount of damage was generally due to larvae of various insects.

Red oak and white oak acorns from the good site were highest in ash, calcium, and nitrogen-free extract, and lowest in ether extract. Red oak was also lowest in protein. White oak and black oak acorns from the medium site were highest in protein.

If the three stands are evaluated on the basis of food for squirrels, the white oak-black oak type on the medium site appears to be of greatest value.

The Biology and Control of Maggot Complex Associated with Spinach

GUYER, GORDON; NORMAN REATH AND KEITH HAISLEY

Jour. of Econ. Enty. 50:595-598. 1957. (Journal Article 2051 from the Michigan Agricultural Experiment Station)

A 3-year investigation was initiated to study the biology and control of the maggot complex (budworms) associated with the buds of spinach. Eleven species of flies representing six families were reared from infested spinach. A single species of *Drosophila* was responsible for 71 percent of the population.

Foliage treatments with the chlorinated hydrocarbon insecticides were generally more effective than the phosphate materials. Foliage applications with granulated carriers were more effective than conventional spray treatments. Residues in canned spinach sampled 3 days after treatment were generally absent or below the established tolerance for the materials included in the study. Both the performance data and the residue studies indicated that granulated dieldrin and parathion were the most promising materials for control of the maggot complex on spinach.

Experimental Ovine Leptospirosis—*Leptospira promona* Infection

MORSE, E. V.; R. L. MORTER; R. F. LANGHAM; ATHALIE LUNDBERG AND D. E. ULLREY

Jour. of Infectious Diseases 101:129-136. 1957. (Journal Article 2052 from the Michigan Agricultural Experiment Station)

Both bovine and porcine strains of *L. pomona* will produce disease in sheep following subcutaneous inoculation. The infection may be contracted subsequent to contact with infected hogs.

Hyperpyrexia, hemolytic anemia, and hemoglobinuria represent the severe manifestations of the disease. Icterus and lameness may also occur.

Hematological features include a marked decrease in erythrocytes and low hemoglobin levels. A mild leucocytosis may be observed while the differential leucocyte counts are essentially unaltered.

The renal tissues contain leptospirae by the eighth day and demonstrable leptospiruria is observed at 14 days. Forty-four days probably represent the maximal duration of the carrier state for most sheep; however, one animal eliminated leptospirae in the urine for 62 days, but not 65 days.

Although sheep are susceptible to *L. pomona* infection, the animals probably play only a minor role in the transmission of the disease. Normal sheep, hogs, and goats did not become infected following 5 weeks contact with infected sheep.

Pipeline-Milker and Bulk-Tank Milk Filtration

JENSEN, J. M. AND LOUIS JOKAY

Jour. of Milk and Food Tech. 20:230-235. 1957. (Journal Article 2057 from the Michigan Agricultural Experiment Station)

The filtration efficiency of various materials used in pipeline filters showed that the best filtration was secured using (a) non-woven cotton discs, followed in order by (b) flannel fabric, (c) muslin fabric, and (d) flannel fabric after use in four milkings. However, bag filters of flannel and muslin gave inadequate filtration.

The tests were made using a milk flow splitting apparatus, dividing milk equally between two kinds of filter materials, and by measuring the number and size of sediment particles found in 1 square centimeter areas of Lintine sediment testing discs after drawing samples from bulk tanks. Best uniformity in numbers of particles was secured when testing 1 gallon portions.

The Inactivation of Pyridinethione, an Antifungal Agent, by Glucose

RINGEL, S. M. AND E. S. BENEKE

Mycologia 49:636-643. 1957. (Journal Article 2060 from the Michigan Agricultural Experiment Station)

A further evaluation is made of the effects of glucose on the antifungal activity of pyridinethione with respect to concentration and time. *Collectotrichum phomoides* (Sacc.) Chester was used in the bioassay studies. By means of spectrophotometric and bioassay techniques, it has been shown that the reducing sugar D-glucose inactivates the antifungal compound sodium pyridinethione. This is dependent on time and the concentration of the reactants. It is accelerated in the presence of phosphate. The chemical interaction between glucose and pyridinethione is discussed.

Effects of Silvicultural Practices on Wildlife Food and Cover in Oak and Aspen Types in Northern Michigan

GYSEL, L. W.

Jour. of Forestry 55:803-809. 1957. (Journal Article 2073 from the Michigan Agricultural Experiment Station)

An analysis was made of experimental areas in which red pine was released from overstory oaks by axe girdling and cutting, by chemical basal spray, chemical in frills, and chemical applied as an aerial spray. Four to 5 years later the mixture of pine cover, various plant species suitable for browse, and dense low summer plant cover, including berry producing plants, provided a diversification of vegetative conditions which apparently improved the range for deer, grouse, rabbits, and many non-game animals.

The dominant cover after the cutting of aspen was mainly aspen root suckers which provided two or more times the weight of browse produced as the result of treatments in the oak stands.

The utilization of tree seedlings, sprouts, and shrubs by deer and rabbits in the oak and aspen areas in no way interfered with the silvicultural objectives.

Sorbic Acid as a Selective Agent for Cucumber Fermentations III. Evaluation of Salt Stock from Sorbic Acid Treated Cucumber Fermentations

COSTILOW, R. N.

Food Tech. 11:591-595. 1957. (Journal Article 2075 from the Michigan Agricultural Experiment Station)

It has been demonstrated a number of times that gaseous fermentations by yeasts are often responsible for bloater spoilage of cucumber salt stock. A 3-year study using sorbic acid in concentrations of from 0.01 to 0.10 percent to control yeasts, and involving 123 experimental cucumber fermentations has been completed. The salt stock from these fermentations was evaluated with respect to bloater-type spoilage, cure, firmness, and color.

The occurrence of severe bloaters and poor seed cavities was reduced by approximately 75 percent, but the incidence of small separations was not changed

significantly by the treatments. Sorbic acid treatments from 0.02 to 0.10 percent were equally effective in bloater control, but 0.01 percent sorbic acid was less effective.

The curing of the salt stock was delayed in some instances by sorbic acid. This was observed most frequently with stock from fermentations where the average temperature during fermentation had been relatively low and/or where a high salt level had been used in the initial brining. The effect on curing was greater with increasing sorbic acid concentrations.

Sorbic acid treatments of 0.05 and 0.10 percent frequently resulted in a bleaching of the salt stock. In a few instances, lower concentrations had the same effect. The firmness of the salt stock was not significantly affected.

Effects of Jar Size, Liquor, and Product-to-Liquor Ratio on Heating Characteristics of Fresh-Packed Pickle Products

NICHOLAS, R. C.; I. J. PFLUG AND R. N. COSTILOW

Food Tech. 11:488-490. 1957. (Journal Article 2079 from the Michigan Agricultural Experiment Station)

The effects of jar geometry, liquor, and product-to-liquor ratio on lag factor, heating rate, and sterilizing value were investigated for fresh cucumber pickle products. These heating characteristics have been tabulated for slice and spear products packed in different jars and covered with brine or syrup. Syrup packs were found to heat more slowly than corresponding brine packs; increased pickle-to-liquor ratios yielded higher lag factors, but unchanged heating rates, and lower sterilizing values.

Potentialities of Multiple Price Plans for Improving Agricultural Trade Relations

WITT, LAWRENCE W.

Policy for Commercial Agriculture, Subcommittee on Agricultural Policy, Joint Economic Committee, 85th Congress, 1st Session. pp. 585-598. 1957. (Journal Article 2148 from the Michigan Agricultural Experiment Station)

The importance of government aid in maintaining agricultural exports was emphasized. American agriculture has had difficulty exporting for the following reasons. Agriculture has lost some comparative advantage. Foreign agricultural capacity has expanded. Economic development abroad has increased the demand for industrial goods. Agricultural export programs are complicated because foreign markets are important to some sectors of American agriculture, strengthening domestic farm income interferes with exports, other countries may depend on a few agricultural exports, and food plays a vital role in a nation's well-being.

Alternative export sales policies were considered. Any sales program leads to conflicts of interests between U. S. and other exporters, between agricultural and industrial exporters and taxpayers, between present markets and future markets and between producers and consumers in other countries. To resolve these issues intelligently requires more knowledge of the effects of these programs than is now available. It was urged that Congress encourage and facilitate such studies.

(Continued from back cover)

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The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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BRATZLER, L. J., M.S.....Assoc. Prof. of An. Husb.
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HUFFMAN, C. F., Ph.D.....Prof. of Dairy
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EVERSON, E. H., Ph.D.....Assoc. Prof. of Farm Crops
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HARRISON, C. M., Ph.D.....Prof. of Farm Crops
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GYSEL, LESLIE, Ph.D.....Assoc. Prof. of Fisheries and Wildlife
ROELOFS, E. W., Ph.D.....Assoc. Prof. of Fisheries and Wildlife

Foods and Nutrition

KELLEY, A. L., Ph.D.....Assoc. Prof. of Foods and Nutrition

Forest Products

WYLIE, A. E., Ph.D.....Prof. of Forest Products

Forestry

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ROBBINS, P. W., M.S.....Assoc. Prof. of Forestry
WHITE, D. P., Ph.D.....Assoc. Prof. of Forestry
WRIGHT, J. W., Ph.D.....Assoc. Prof. of Forestry

Home Management and Child Development

GROSS, IRMA, H., Ph.D.....Prof. of Home Man. and Child Dev.
THORP, A., Ph.D.....Assoc. Prof. of Home Mgmt. and Child Dev.

Horticulture

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BELL, H. Ph.D.....Assoc. Prof. of Hort.
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CAROLUS, R. L., Ph.D.....Prof. of Hort.
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